METAL PROGRESS

DECEMBER, 1941 VOLUME 40, NO. 6

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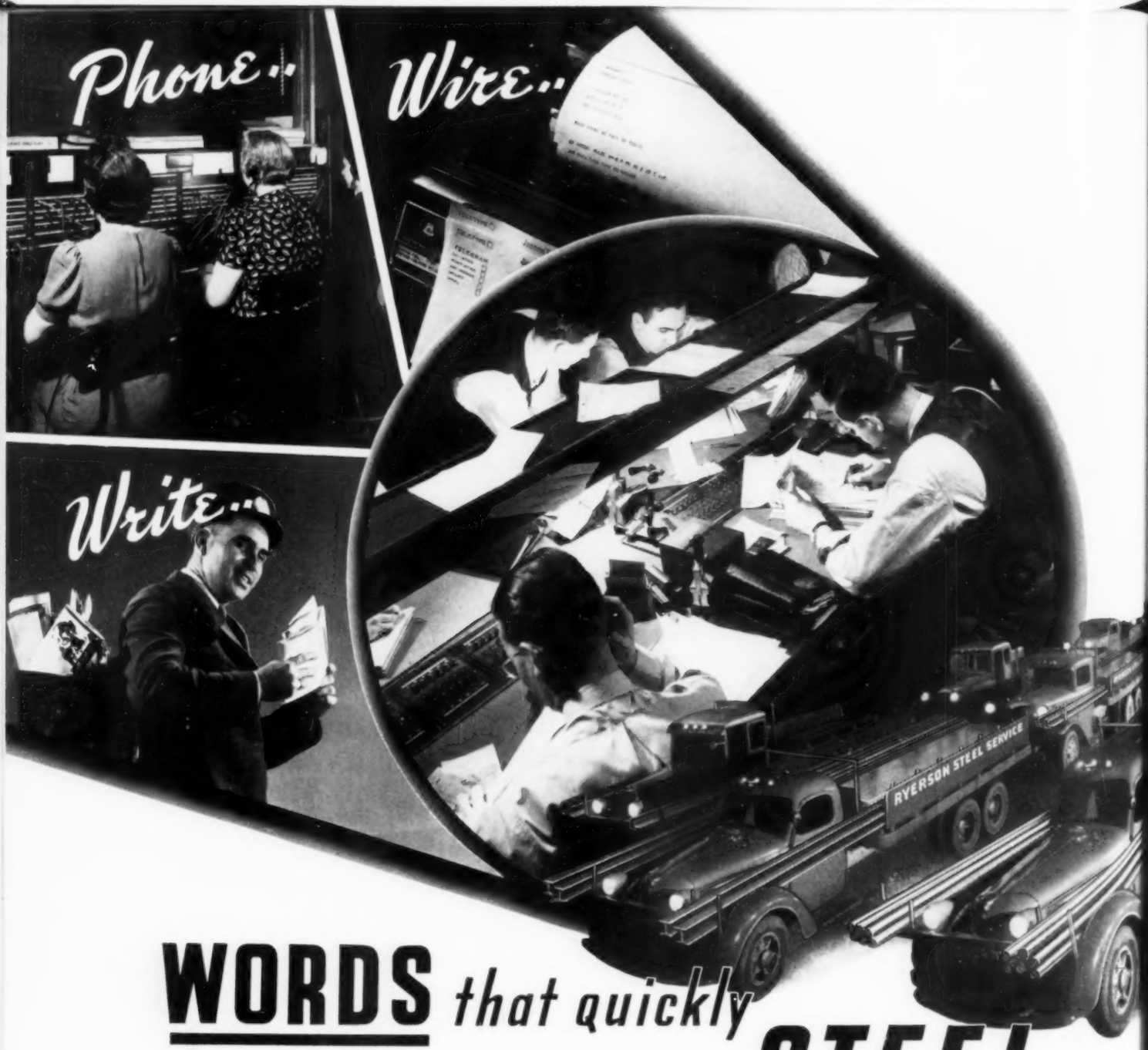

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The National Defense Group Meetings at the National Metal Congress in October got off to a good start with a discussion of the low carbon alloy steels for casehardening. The panel of experts included Messrs. Williams, Hildorf, Barron, McCleary, McQuaid and McMullan — where could you pack more information into as small a group? Mr. McCleary's contribution was an unusually concentrated distillation of a lifetime's experience with steel.

ECONOMICS OF METAL USE

By FRED E. McCLEARY

Metallurgical Engineer, Chrysler Corp. and Dodge Bros. Division, Detroit

MR. CHAIRMAN and Gentlemen:

I have been asked to compare the scarce steels with the steels which will be obtainable, as far as their fabricating properties are concerned.

There is not sufficient time to make comparisons. There is only time to tell you a few facts. Bear them in mind in handling any new steel, or any old steel, for that matter.

I do not make or sell steel. So — I do not have any fear of tramping on customers' toes. I am not interested in 1941 cars — they're all made. Steel for 1942 products is on order.

I am not going to speak of today, but of the years ahead.

Briefly I express my opinion concerning non-defense steel, and perhaps some defense steel in the necessitous days of the future. I propose to discuss the economic way to use it. I shall quote a few facts that should not be overlooked.

ECONOMICS

The selection of steel types and the number of types specified by any single organization has, in the past ten years, been based to a considerable extent upon economics.

During the present emergency, they must be based on economics and availability.

After the emergency you and I will take up a few notches in our mental belts and apply economics to the practice of metallurgy as we never have before, or be pushed out of our pleasant places by a group of green light go-getters who will not act as our mental crutches.

We will of necessity

1. Simplify and reduce the number of steel types;
2. Study, analyze and coordinate all shop equipment and processes;
3. *Cooperate* — and I mean cooperate fully with production divisions, engineering departments and purchasing, and with suppliers and vendors; and finally
4. We must produce parts or units that will perform satisfactorily on the median line of predetermined requirements.

We will not be able to stand the expense of using gold where silver is satisfactory. We cannot be responsible for sales inhibition through service failure.

Today you are forced to make a decision:

1. Do you think the emergency will be short? or
2. Do you think it will be a long pull?

If the first, do not listen to me, because I am going to discuss conditions and materials for the long pull.

We are not going to be able to drag in sufficient alloys from the various corners of the earth to supply non-defense requirements, even in part. Defense production *may* get what it desires.

There isn't any doubt but that non-defense which needs something that alloy steels alone

can give will soon have to be content with domestically produced alloys. Today, and as far as I can see into the future, that alloying element will be molybdenum. Perhaps we shall later have some others. Be that as it may, my further remarks will apply to all.

We will undoubtedly have to use less than 1% manganese in our alloy steels. Maybe considerably less. Therefore, the amount of alloy used will be governed largely by the desired hardenability.

For carburizing, you should use a fine-grained steel with a minimum coarsening temperature of 1750° F.

Machinability

1. *Grain Size.* Many of you have been using fine-grained steel. The others will probably have to use a little more rake on their tools to get desired cutting speed.

2. *Microstructure.* Uniformity of structure is very effective. A good anneal is desirable; cycle anneal, if possible. This is especially true for gears.

Don't get too much upset by metallographic reports of pseudo something or other. Ceramic inclusions and dirt will be worse than all the pseudos yet found.

3. *Carbon Content.* Keep carbon as high as core hardness will permit. You know that you can condition a 0.30 to 0.35% carbon steel (if it isn't air hardening) to better cutting properties than any other carbon content.

I use 0.25 to 0.30% carbon steel for ring gears, and give them a 0.050-in. case.

I use 0.30 to 0.35% carbon for transmissions —0.035-in. case.

Cycle anneal rings at 1725° F. for 2 hr., cool to 1000° at a rate of 290° per hr. to 600° F., then 133° per hr. Brinell hardness is 146 average (better would be 160).

Cycle anneal transmissions at 1700° for 2 hr. Cool in fan chamber to 1080° in 15 to 20 min. Load in skid box and allow to cool slowly. Hardness: Average 178.

4. *Sulphur* additions are of great benefit.

For example, on ring gear steels, the heat melts to 0.015 to 0.020% sulphur, and the steel maker adds 0.020%. We use a maximum of 0.045% sulphur.

This has increased the number of ring gears per tool grind nearly 50%. (This figure is based on the use of approximately 15,000,000 lb. of added sulphur ring gear steel.)

Speed of Carburization

1. *Grain Size.* Coarse grain and some alloys increase penetration somewhat.

2. *Temperature* is the greatest effective.

3. *Limitation.* Speedy penetration is generally undesirable because of surface carbon concentration, and the retention of austenite in quenching.

4. *Program.* Low alloy fine-grained steels take a 0.035 to 0.040-in. case in 3 hr. at 1680° F. That is the time *at heat.* They are above 1600° F. for 4 hr., either in pack hardening or gas carburizing.

Austenite in Case

1. If surface austenite is desired, a surface carbon of 1.15% or over is indicated. Austenite in the quenched structure means Rockwell C-57 hardness maximum, which scores rather easily. It cannot then be remedied because of the subsequent work hardening, and scored gears remain noisy. Modern inability to endure a "running-in" period does not give time to cold work austenite surfaces, slowly.

2. To keep austenite to a minimum and hardness well above C-60, carbon should be 1.10% maximum.

Uniformity of Hardness

I will not discuss those known conditions of mass, coolant temperature, coolant turbulence and fixture or die quenching.

Important points concerning composition and structure are:

1. Use well killed steel with 0.20 to 0.30% of residual silicon. Better still if a small amount of aluminum is added to the steel ingots. There will be no soft spots in fine-grained non-normal steel so treated.

(Some of the fine-grained steels of today are called "abnormal". They should really be called "non-normal". They are not at all abnormal in the sense that they injure uniformity of hardness or cause soft spots.)

Strength and Toughness of Core

1. In *double quench,* the core will generally be of low strength and high impact resistance. This is due to low core hardness.

2. In *single quench,* which should be from the carburizing temperature, the hardness of

the core will depend on the amount of carbon, manganese and alloy. It is therefore under perfect control. The strength will be directly proportional to the hardness. Toughness will be inversely proportional. For ring gear teeth: Rockwell C-30; for transmissions, C-40.

Nature of Quench

1. Economy, lower distortion, and controlled core hardness indicate the desirability of the single quench. Grain size will remain unchanged if the steel's coarsening temperature is 50° or more above carburizing.

2. The coolant temperature and turbulence distribution should be held to give just the desired results. Drastic conditions are undesirable. Quenching strain should be kept to the minimum.

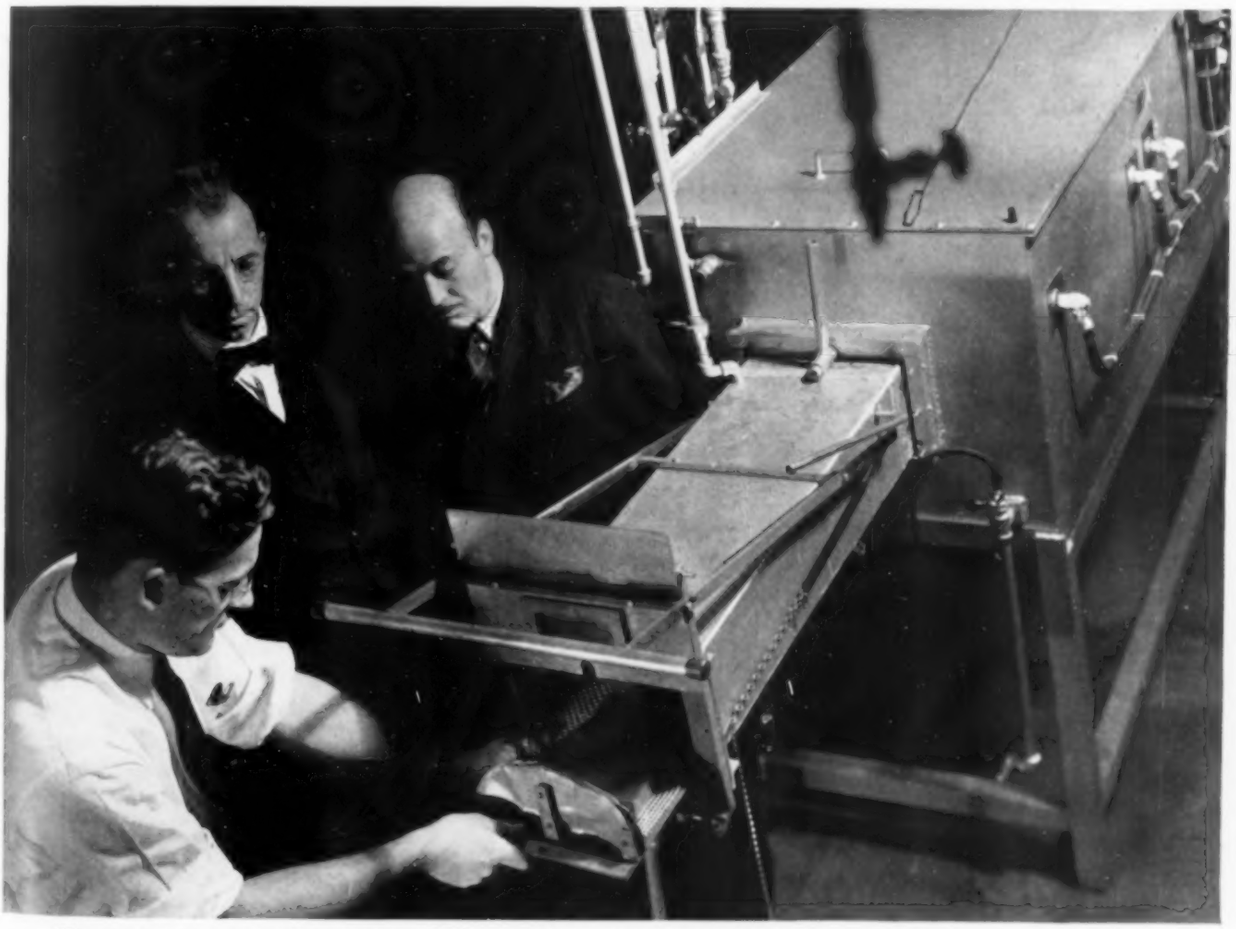
3. Water is seldom necessary or desirable. Its total cost is generally higher than oil.

Distortion

1. The quench must be uniform. Have enough well directed turbulence until the piece is cooled beyond the nose of the "S" curve.

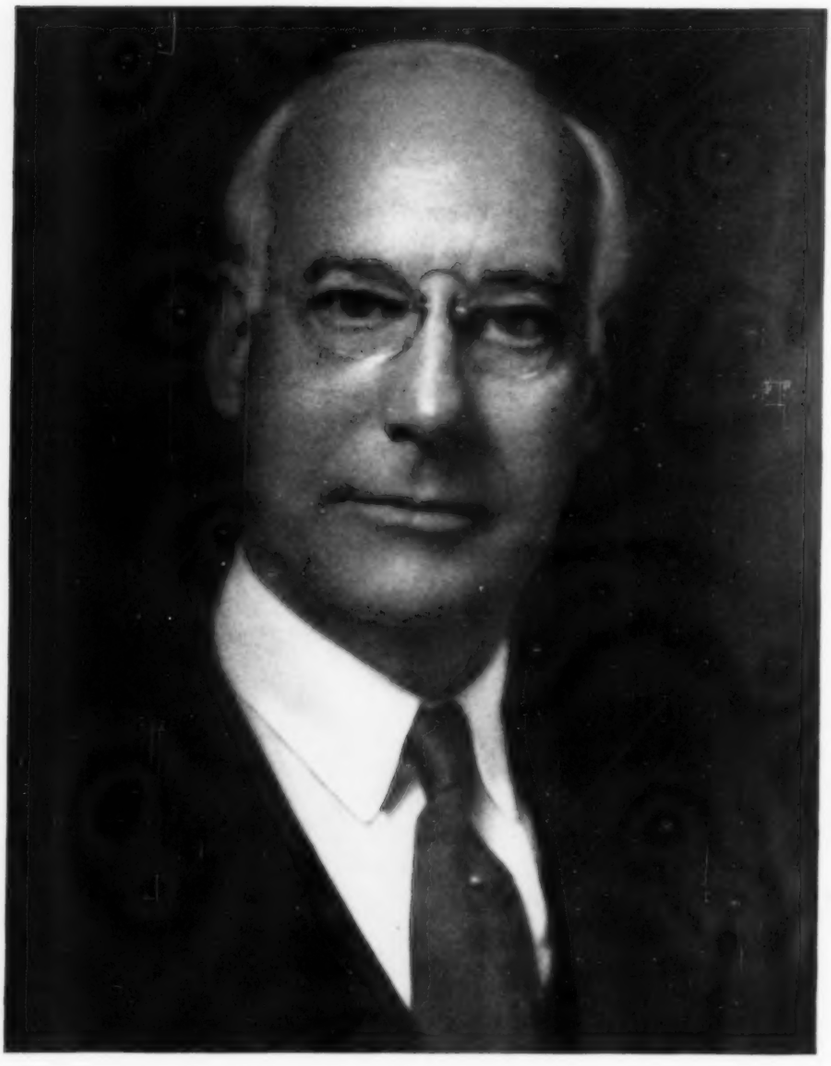
2. The most important point is to keep the cutting effort as low as possible. The steel must not be too hard or too soft. This is especially true of gear teeth. Material that cuts hard has a lot of strain introduced into it by the cold work. This strain is relieved in carburizing, with resulting tooth distortion and often a rise or fall of the pitch line. Most distortion of this kind occurs during carburizing, *not* during the quench. This increases the lapping required, which is expensive. It creates a bad tooth form which is detrimental; it lowers the gear life. Therefore, get the best cutting possible.

Sprockets and large gears are best surface hardened by flame or induction. This is a future possibility on small work.



Howard Scott and Allan Bates, of Westinghouse's Metallurgical Research Laboratory, Do Some Concentrated Observing While T. H. Gray Charges a Load of Dies Into a Hardening Furnace

BIOGRAPHICAL NOTES OF EMINENT METALLURGISTS



Bradley Stoughton

PRESIDENT, AMERICAN SOCIETY FOR METALS

Metal Progress; Page 884

THE COAL AND IRON AGE, beginning about 1850 in America, was, according to LEWIS MUMFORD's critical pen, marked by a new barbarism. Life values gave way to pecuniary values. It was no longer sufficient for man's industry to provide a livelihood, it must create him an independent fortune; work was no longer a necessary part of living, it became an all important end. The environment was destroyed by pollution of the air with clouds of smoke and near-poisonous gases, the streams with chemicals and sewage. Crowding into cities brought epidemics of disease. Specialization of a region in one industry brought insecurity of employment, a lop-sided social life, and an impoverishment in intellectual resources. The degradation of the worker followed, child labor was universal, early death was the norm among the laboring class. Specialized factory machinery robbed the worker of skill and made him a machine tender. Poverty prevented his migration. Social conscience and *noblesse oblige* disappeared. Not until 1910 did an opposite trend set in.

Viewed against this barbarous background, the achievements, character and personality of BRADLEY STOUGHTON take on increased significance. Son of Col. CHARLES BRADLEY STOUGHTON and ADA RIPLEY HOOPER (the latter, in Prof. WILLIAM CAMPBELL's words, "the embodiment of the best traditions of Back Bay Boston"), BRADLEY STOUGHTON possesses a high sense of social obligation. Under the glass of his desk for years was a quotation from DICKENS' Christmas Carol, "Mankind Is My Business". One instance: When President HARDING undertook to advocate the eight-hour day in industry and to prepare a "white paper" on the subject, he asked STOUGHTON to write the chapter on the iron and steel industry. In those days the official industrial view was that the workmen themselves wanted a longer work-day, so any opposition took courage, but STOUGHTON believed the cause was just and did his part —one of the necessary preliminary steps to the adoption, almost universally, of the eight-hour day throughout industry.

Like everyone else who associated with HENRY MARION HOWE, until his death dean of the world's iron and steel metallurgists, STOUGHTON's early professional life was markedly influenced by years of joint labor at Columbia University, first in 1897 as HOWE's private assistant, and later as adjunct professor from 1902 to 1908. Here he became acting head of the metallurgy department. In those days, by virtue of an incomparably brilliant faculty, Columbia's School of Mines and Metallurgy had replaced Freiburg as the world's best. JOHN V. W. REYNDERS writes of this period: "BRADLEY STOUGHTON, in addition to his own important contribution to the science and art of steel making, has exemplified in his professional attitude the great tradition linked with the name of HENRY MARION HOWE, under whose influence as student and associate he rose to high estate as the intellectual heir of this inspiring leader."

In 1912 he became secretary of the American Institute of Mining and Metallurgical Engineers and remained for ten years in that position. During the World War, the "Founder Engineering Societies", including the A.I.M.E., advocated an Engineer Reserve, which was later extended to form the Officers Reserve Corps. Col. ARTHUR S. DWIGHT has said of this work: "I had much to do with BRADLEY STOUGHTON, secretary of the Institute, whose earnest cooperation and enthusiastic support of the movement did much to contribute to its success." When America entered the war, Professor STOUGHTON spent half of his time in Washington as vice-chairman of the engineering division of the National Research Council. The present emergency also finds him ready; he is chief of the unit in the Office of Production Management that studies, advises upon and allocates heat treating equipment.

In 1923 he came to Lehigh University to succeed the lamented JOSEPH W. RICHARDS as head of the department of metallurgy, later becoming also dean of engineering. His text book on "The Metallurgy of Iron and Steel", first written in 1908, here received successive revisions and remains the standard work on the subject for college instruction. Prof. THOMAS T. READ of Columbia University appraises it thus: "The remarkable clarity of its presentation and the orderly arrangement of material make it the book to which I still turn after all these years."

STOUGHTON has always been gladly willing to give of his time and talents to his fellow engineers. His long and intimate connection with the American Institute of Mining and Metallurgical Engineers has already been noted. He was in 1931 president of the American Electrochemical Society, and was the Grasselli Medalist of the Society of Chemical Industry in 1929. He joined the American Society for Metals very early in its life (1923), was chairman of the Lehigh Valley Chapter in 1934, and since 1938 has been on the Board of Trustees of the national society, for two years as treasurer, then vice-president and now president.

BRADLEY STOUGHTON has given time without stint to his students, helping them to decide the directions in which their careers should lie, counselling his colleagues, for his ability, demonstrated so often in patent trials to see the crux of a complex case, is almost uncanny and, needless to say, has been invaluable to industry in both technical and legal consultations over a long period.

"His intimate knowledge of the theoretical and practical problems of the manufacture of steel, combined with a charming personality, have made him an outstanding figure with his students and the men of our industry. It is characteristic of him that today he should add to an already full schedule the responsibilities of his time, advice, and experience in helping materially with our National Defense Program at Washington." So writes QUINCY BENT, his neighbor and fellow vestryman.

BRADLEY STOUGHTON combines professional achievement with that broad sympathy and mature judgment which can guide the American Society for Metals in the strenuous days ahead. The Society congratulates itself on its leadership.

SUPPLY OF ALLOYS FOR CAST IRON*

By HAROLD S. AUSTIN

Foundry Metallurgist, Buick Motor Division, Flint, Mich.

A PORTION of the data about the situation of foundries in the automotive industry which I have gathered together for presentation here was obtained from friendly sources, principally foundry metallurgists, purchasing agents, and representatives of ferro-alloy producers.

In respect to the supply of ferro-alloys, all agreed that with the exception of nickel, the foundries are receiving sufficient alloys to take care of their present needs.

For civilian use, nickel is out of the picture. Cast iron scrap, especially auto cast which has accounted for an appreciable amount of nickel and chromium in the furnace charge, is extremely scarce. The percentage of nickel in the iron as tapped has been steadily decreasing in the past few months, and is now down merely to residual amounts. This decrease in nickel is noticeable in the machine shop, and is responsible for a somewhat more difficult machinability. As a result of this deficiency in cast scrap, inventories have and are dropping to a low figure. The materials left to fill the gap are pig iron, scrap steel, scrap bundle steel, iron and steel borings. This shortage of available charge materials has created a further problem of maintaining unchanged the desired physical standards of the iron casting.

In the production of castings for passenger automobiles, some companies require neither nickel nor chromium in the composition of the iron; others generally use only small percentages, ranging from 0.15 to 0.50% of either nickel or chromium or both. There has been some concern about the supply of chromium, but I

*Notes presented at National Defense Group Meeting on Conservation and Substitutions in Alloy Castings, Convention, Philadelphia, Oct. 23, 1941.

have been told from several sources that there should be an ample supply provided shipments of imported stocks are not cut off. One interesting fact is that a portion of our chromium is now being supplied from low grade ore deposits located in North America.

Copper is being used more and more in automotive cast parts. There are several foundries using this element in both steel and iron castings, varying in amount from 0.5 to 2.5%. As scrap copper is used for this purpose, no difficulty has been experienced in getting the metal. With the latest restrictions now in effect, this situation may change radically.

Truck castings and diesel parts usually contain combinations of nickel-chromium, nickel-chromium-molybdenum, and chromium-molybdenum. This is especially true of castings where heat resisting properties, resistance to cracking, and increased strength are necessary. Trucks come under a blanket priority A-3, and perhaps this has something to do with the circumstance that there has been no difficulty in getting all of these metals for alloying purposes. Brake drums, cylinder sleeves and exhaust manifolds are other types of castings that are often alloyed, and may include any or all of the three metals, nickel, chromium and molybdenum, the amounts depending upon the severity of the service condition.

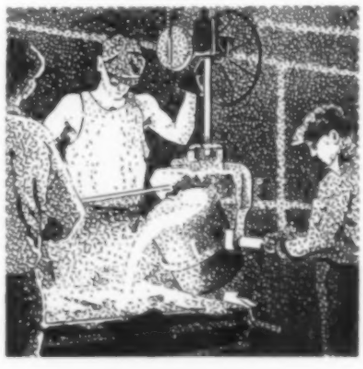
Molybdenum is used extensively in cast iron crank and cam shafts and other cast iron and steel parts where increased strength, wear, impact and improved flame hardening properties are required. The largest known deposits of molybdenum ores are found in the United States, and it is said that the supply should be adequate for all purposes.

One of the elements absolutely indispensable in ferrous castings is silicon. Anywhere from 1.75 to 2.5% of silicon is required in automotive gray iron castings, and in small piston rings and numerous other light castings even larger amounts are used. It is introduced into the furnace mixture generally through the medium of pig iron, silvery iron or ferrosilicon in various forms. A certain percentage of silicon is lost during the melting process — usually about 10% — and as all automotive foundries include steel scrap in the furnace charge, the slag loss may range from 10 to 60% and sometimes even more. Therefore large quantities of silicon must be added to the charge in one form or another in order to hold the percentage of silicon up to the required amount in the casting as poured. Ferrosilicon has been "rationed" by the producers since early summer; power shortages at furnace plants are largely to blame, but apparently no necessary work has been delayed. There has been some difficulty in getting silicon as well as manganese through the accustomed channels, and maneuvering around from one source to another has been necessary sometimes in order to obtain sufficient requirements and to prevent a curtailment of production.

As far as I have been able to determine, there has not been any sensational substitutions of more plentiful metals for the scarcer metals. Ladle additions of 0.20 to 0.30% of ground ferrosilicon with a possible 0.60% reduction of silicon in the furnace charge is said to produce the equivalent physical properties in gray iron with a net saving of 0.20 to 0.30% in silicon. Similar savings are claimed through the use of briquetted silicon carbide. A number of foundries are making ladle additions of natural or synthetic graphite in place of ferrosilicon and thereby conserving the silicon otherwise needed for graphitizing the combined carbon.

From information which I have obtained from automotive foundries, I would estimate present average production around 65% of capacity. In foundries where truck and defense castings are being made the rate is generally higher, with a lower rate in foundries not so engaged.

With drastic reductions in production schedules ahead for an indefinite period, the automotive industry is facing a grave emergency. Castings for use in other industries and displacing other overcrowded processes may be the answer. Every possible lead should be investigated for the purpose of uncovering this new work in order to keep the industry busy. Anticipated shortages of pig iron and scrap will add to the difficulties.



As outlined by Zay Jeffries in the leading article in Metal Progress last month, the Advisory Committee to O.P.M. on Metals has submitted several reports on the conservation of manganese and substitutes therefor. The drafts were prepared by H. W. Gillett of Battelle Memorial Institute, and are reproduced here, in part. The Committee believes that some 20% of the manganese normally used by the steel industry could be conserved by certain expedients, if consumers would accept material with less excellent surface condition.

EMERGENCY CONSERVATION OF MANGANESE

By Advisory Committee to O.P.M. on Metals, National Academy of Sciences

THE AMERICAN iron and steel industry requires annually about 1,300,000 tons of high grade manganese ore (containing 50% manganese) to produce its goal of 90 million tons of ingots. Seven-eighths of this ore is now imported. The following statement outlines what can be done in the way of lessening manganese consumption; it is to be understood that these proposals are directly applicable only if an emergency should restrict the foreign supply, that the adoption of some of them will require the cooperation of the consumer, and in addition will result in some increase in real cost.

Manganese is, normally, one of the cheapest alloying elements for steel and is used in the largest amount. There is a fairly large, though hardly inexhaustible, supply of low grade domestic ores, but the know-how for reasonably economic utilization of them is still lacking, though it is being sought. On the outcome of such studies rests the degree to which manganese can continue to be utilized in its replaceable applications.

The amount of manganese required in steel making is determined mainly by two metallurgical factors: *(a)* To offset the adverse effect of sulphur upon hot-working properties and surface quality, and *(b)* to secure in the finished steel certain properties desired by the consumer. Manganese also acts to some extent as a deoxidizer. The amount actually used, which is now on the average about 12.5 lb. manganese metal per net ton of steel (15.6 lb. of 80% ferromanganese) is the result of a balance between the cost of additional manganese on the one hand, and on the other the added mill cost resulting from the use of too little manganese.

Manganese content of most steel products has been steadily increasing because the consumer demanded better and better quality of surface both of steels used in the as-rolled condition and of steels to be converted by him into finished products. In other words, present practices have been developed to yield the best quality of finished product at the lowest practicable overall cost under normal operating conditions. It is to be emphasized, therefore, that any change designed to lessen the content of manganese would increase the real cost to the steel mill and to the consumer, even though the standard of surface quality is relaxed to the extent to which this can be done without affecting the actual practical fitness of the product; moreover unless the consumer will cooperate in this matter, such a lessening of manganese content will tend to a further increase of cost to the producer and consumer and to a decrease of rate of production of satisfactory material.

A survey of the major steel products leads to the conclusion that, *provided the consumer*

will cooperate, the use of ferromanganese could be lessened by about 20%. This annual saving is equivalent to about 250,000 tons of ore of 50% manganese, an amount considerably greater than the immediate possible production from any domestic source now known.

Conservation in Steel Making

The foregoing refers to the final product; let us now consider the possibilities in the steel making process.

Manganese enters in the pig iron, in the scrap, and as added ferromanganese or other manganese alloy; it leaves in the finished product and in the slags. The total amount of manganese lost to the slag is at present equivalent to more than 500,000 tons of high grade ore annually, this amount being exclusive of that now returned to the blast furnace for re-smelting. Slag is a very low grade "ore" which, though available at the steel plant, cannot be commercially utilized. However, this possible resource should be considered in conjunction with other low grade, but less accessible, ore deposits.

Less ferromanganese will be needed if we can increase the proportion of manganese retained in the metal either from that charged as a constituent of the pig iron and scrap, or from that added as ferro-alloys. It is believed that appreciable aggregate savings of ferromanganese can be effected by careful attention to the following points; to learn how far it is *practicable* to proceed in any of these directions will require very careful consideration of the possible influence of such modifications of practice upon rate of production, cost and quality of product. Since one of the functions of manganese is to counteract the harmful actions of sulphur in steel, it is obvious that if less sulphur were charged into the furnaces with the ore, flux, scrap and fuel, or the sulphur in pig iron reduced by treatment with alkali or otherwise, manganese could be conserved, but at a cost.

It is to be emphasized that the following statements, though valid for a considerable fraction of the total tonnage, are not applicable to all grades and types of steel; that steel makers have, in recent years particularly, been doing everything they can to use manganese most economically; and that some of these procedures, though they may save ferromanganese, will undoubtedly increase costs.

1. *Regulation of Manganese Content of Pig Iron.* Only from 10 to 20% of the manganese put into the openhearth furnace in the pig iron and scrap is recovered in the steel. The actual amount depends on the grade of steel being made and on the proportions of pig and scrap used. As the manganese input increases, there is generally some increase in the amount of manganese retained in the steel and a corresponding small decrease in the ferromanganese requirement. In some cases, where the maximum permissible content of phosphorus could be raised, a greater proportion of basic openhearth slag could be returned to the blast furnace for re-smelting, thereby producing an iron of somewhat higher manganese content. In other cases domestic manganiferous ores can be used, though this is usually a more expensive method, again because of the low recovery of manganese in the steel.

2. *Lowering the Slag Volume of the Openhearth Furnace* by any method, provided it is of proper composition, will lessen the amount of manganese lost to the slag. One way is to lower the silicon content of the pig iron and to keep silica from other sources to a minimum.

3. *Increasing the Efficiency of Ferromanganese Additions.* The manganese yield obtained from alloying additions of ferromanganese made to bring the manganese content of the steel up to the specification, depends upon many factors. Careful slag control will increase the residual manganese. Almost without exception the yield from furnace additions is lower (about 10% lower) than from ladle additions; in the interest of conserving manganese, the latter method should therefore be used to the fullest practicable extent. In the production of many steel grades required in substantial quantities, manganese yield may be increased without detrimental effect upon steel quality by using a preliminary deoxidizing addition (such as 10 to 15% ferrosilicon), as is now practiced in the melting of certain other steels.

4. *Substitution of Other Metals.* Equivalent physical properties may be obtained by substituting other (more expensive) metals for manganese in many of the higher manganese steels. Such a substitution might involve some modification of heat treatment, or the tensile specifications, but would be primarily a question of added cost. The same would be true of lowering the manganese content and improving the quality of the heat treating operations. These considerations will now be discussed in some detail.

General Considerations

Unless thought is taken in selecting a substitute or several substitutes for a scarce metal, the results are likely to be the creation of new bottlenecks. The *value* of alloying elements is somewhat measured by their present cost, which reflects the man-hours required — but not entirely, since some of the cheaper as well as some of the more expensive elements are unique in the properties they confer. For instance, the roles of vanadium in high speed steel, of chromium in stainless, of manganese in controlling sulphur so as to make steel rollable, cannot today be played by any other elements. The strengthening effect of these elements can, however, be obtained in a variety of other ways.

Among alternate elements, the one to be chosen under present conditions is the one available in the greatest profusion in domestic ores (with due regard to man-hours required in production of the metal), or if importation must be made, the one that can be imported in the least heavy or bulky form (high grade ore) over the shortest shipping route.

At the present time these considerations, and the application of priorities, limit choice to a relatively few elements:

Carbon may be used at will, but its employment is limited by the lack of toughness of high carbon steels.

Silicon is available in utmost profusion as silica. By use of man-hours and electric energy we can have as much ferrosilicon as we want.

Phosphorus is in the same category as silicon; there is plenty of phosphate rock. Both silicon and phosphorus are cheap. Phosphorus is, within limits, a very useful strengthening element for low carbon wrought steels.

Molybdenum is as yet plentiful, coming direct from American ores, and as a by-product from certain copper ores. It is a very potent element, a little does a lot, and in most of its uses in steel it can be employed as the oxide so that no smelting step is necessary. It is relatively expensive, about 85¢ per lb.

Copper is rare just now because of military uses, is a useful alloying element in steel when used in limited amounts (lest edge cracking occur on rolling). It is cheap, 12¢ per lb.

Titanium plays a minor role. It is expensive, $1.25 per lb. Domestic ore deposits are now being developed and with man-hours and electric energy, ample ferrotitanium can be had.

It is obvious that, under present conditions, the substitute alloying elements that can be used without involving shipping or depletion of domestic resources are carbon, silicon, phosphorus, aluminum, and titanium. Next in order come molybdenum and copper. Chromium and manganese need more careful selection of applications than the previous six. Nickel, for the present, needs still more careful scrutiny of uses, and vanadium should be the most carefully restricted of all, from the shipping and depletion point of view, also because it takes the most man-hours and electric energy per pound.

Hence the steels on which to focus attention are *(a)* silicon-molybdenum or plain molybdenum or plain silicon wrought steels, aluminum treated for grain size control when that is necessary; *(b)* low carbon steels employing phosphorus, with or without silicon or molybdenum, and *(c)* cast steels using copper and molybdenum or copper and silicon as alloying elements. Restricted use of chromium, manganese, and vanadium to supplement these basic compositions will, of course, be necessary.

Specific Recommendations

Soft Steel — Somewhere from 0.15 to 0.30% manganese is ordinarily considered essential in steel as a "conditioner" of the molten bath. Almost the only commercial exception is Armco iron, a very low carbon material produced by extreme over-oxidation of an openhearth melt, usually followed by partial deoxidation with aluminum. The commercial "plain carbon steels" normally carry 0.30 to 0.80% manganese. Even in the usual discussions of alloy steels, no attention is paid to the effect of manganese until it rises appreciably above 0.50%. Yet the strength of ordinary structural steel is quite materially higher because of its manganese content. Producers and users have become used to the mill behavior and to the mechanical properties of these carbon-manganese steels and consider them the normal base lines of composition in studies for the evaluation of effects of mill handling, of heat treatment, or of additional alloying elements.

This is especially true because manganese does not prevent the production of rimmed steel. It may be present to over 1% in a rimmed, nonpiping steel, whereas 0.10% silicon or much smaller amounts of aluminum or titanium will kill the steel and prevent rimming. [C. H. Herty pointed out, in a talk before the Ameri-

can Iron and Steel Institute in May, that "in a large tonnage of steels the manganese content is set to assist in developing the best possible surface qualities in the rolled or finished product. A large saving in manganese can be effected through relaxation of the consumers' requirements on surface combined with extra precautions on the part of the producer to reduce the sulphur content of the steel. Such a procedure will no doubt involve some additional costs, but the amount of manganese to be saved by these two steps is considerable."]

Structural Steels — When a killed carbon structural steel is being produced, the required strength of the as-rolled steel may be gained *(a)* by raising the silicon and keeping the manganese very low, or *(b)* by holding the silicon low and running the manganese at the usual level. Rolling properties are not so good with the higher silicon content. Quite a variety of low alloy, high yield strength steels to be used without heat treatment build up some of the required strength by raising the manganese to around 1%. *Use* of manganese in such steels may be good conservation. [For a discussion of this point see November METAL PROGRESS, page 782.]

Increasing the phosphorus and decreasing the manganese could be done in some of these steels, and this same principle might be applied without detriment to a good many other low carbon steels in which phosphorus is ordinarily kept low and the manganese high, provided the sum of the carbon plus phosphorus is kept below 0.25%. Phosphorus is very potent in increasing yield strength, but the steel industry is generally quite conservative in its attitude toward the element.

In these and other strong steels for welding the tendency is to hold the carbon to a low limit and build up strength with manganese, since there is less tendency to crack on cooling from the welding heat than if the carbon were raised.

Strength can also be obtained by raising the carbon, but the accompanying toughness is not as good as with lower carbon and higher manganese. In some special grades of pipe for the petroleum industry and in rail steel, both the carbon and the manganese are raised to the limit beyond which brittleness (low impact test) ensues.

Most of the uses of manganese in steel are predicated on the fact that it has been a very cheap alloying material.

Shell Steel at present usually contains 0.35 to 0.45% C and 1.35 to 1.65% Mn, thus get-

Tank Room in Plant Making Electrolytic Manganese at Knoxville, Tenn.
Photo by Tennessee Valley Authority at Electro Manganese Corp.

ting the required physical properties without heat treatment. One commentator points out that the manganese could be reduced to 0.90 to 1.20% by introducing small amounts of combination alloys that will increase hardenability. Such alloys may require the use of a very small amount of secondary aluminum, this small amount of aluminum serving to substitute for around 0.50% of the manganese otherwise required. Because of the large tonnage of shell steel this would make a real saving. The possibility of compensating for some of the manganese by raising the phosphorus should not be overlooked. Raising the silicon and adding a little molybdenum, or using molybdenum alone would also be feasible, but may be too expensive except in an acute manganese shortage. [See November METAL PROGRESS for notes on this situation. The accepted solution appears to be a lowered manganese content *plus* the heat treatment of shell.]

CAST STEEL

In alloy cast steel, because of its cheapness, manganese normally runs around 1% or over; if other alloys are used they are usually added besides, rather than instead of the manganese. However, strong cast steels lower in manganese are well known; either Cu+Si or Cu+Mo will serve, as is discussed by C. H. LORIG in a paper before the Western Metal Congress, 1941.

Phosphorus is not a feasible strengthening element in cast steels. Cast steel does not have the problem of edge cracking on rolling, so copper may be raised to any desired level. (In wrought steel edge cracking may be avoided by not overheating prior to rolling, or by the addition of a small amount of nickel.)

Engineering Steels — Almost any of the wrought engineering steels that use up to 2% manganese or more could be duplicated at the low manganese level, by use of nickel, or nickel plus a smaller amount of chromium, but this expedient is not available while the nickel shortage lasts. Some degree of substitution of manganese can be accomplished by chromium alone, but nothing would be gained from the conservation point of view.

In steels to be heat treated, replaceability by silicon is limited because it does not induce hardening at depth, which is the chief reason for high manganese in a carbon or alloy steel.

Fortunately, there is an available domestic alloy element, molybdenum, that is very potent in producing depth hardening. Roughly speaking, a 0.30% Mn, 0.25% Mo steel in small sections will have most of the characteristics of a 1.30% Mn steel upon heat treatment. The 1% Mn used for alloying effect is normally only a quarter as expensive as the 0.25% Mo (and probably will be less than half as costly, even when low grade domestic manganese ores are being utilized). Special virtues of its own, however, make the molybdenum steels well worth the price for specific uses. [See the article on manganese-molybdenum steels on page 906.]

From the defense and conservation points of view, with cost no great deterrent, molybdenum can fulfill the great bulk of the strength-giving, alloying properties of manganese, with the added advantage that molybdenum can be added as oxide without having to go through a smelting process. It can be used in both rimmed and killed steels. Steels with manganese held at a very low level and with a wide range of carbon content can be given a range of strength and depth hardening properties suitable for almost any machine part, by proper balance of carbon, silicon, molybdenum, and a little secondary aluminum for grain size control.

In other words, the S.A.E. X-1000 and T-1300 series could be replaced by low manganese steel with a molybdenum addition.

Although molybdenum-manganese-silicon steels are not yet in production, they promise to answer the problem of substitution because a steel with 1% Mn, 1% Si and 0.12% Mo is equivalent to 4615 in hardenability. By increasing the molybdenum up to not over 0.30%, hardenability equivalent to that of S.A.E. 3312 steel may be obtained. By varying the carbon and molybdenum, this steel promises to meet the requirements for all automobile parts. In testing one of this type for roller bearing races, the endurance of the molybdenum-manganese-silicon steel was 250% of that of S.A.E. 4615.

In almost the same category, from the standpoint of range of hardenability and freedom from strategic alloys, is the X-9100 series steel (0.70% Mn, 0.70% Si, 0.15% Mo, 0.50% Cr). The reason these two steels have not been adopted so far has been their somewhat limited machinability.

Free Machining Steels — A very important role of manganese is in the high sulphur, free machining steels of the S.A.E. 1100, X-1100 and X-1300 series, with sulphur ranging up to 0.30%, with or without phosphorus at 0.09 to 0.15%. 0.60 to 1.65% manganese is primarily added in

order that the steel may roll without cracking. These steels are produced in very large tonnages since they are machined vastly more rapidly than analogous grades without the free-cutting additions.

To accomplish this purpose nitrogen is sometimes added, usually with rather low instead of high sulphur and manganese. Aside from this, only very minor additions are ordinarily made to promote machinability in alloy steels, because with high sulphur, the MnS particles which give the steel its easy-cutting behavior are so plentiful that toughness is impaired.

Good machinability may be obtained without appreciable sacrifice of toughness, even in heat treated alloy steels, by adding a little lead, ordinarily less than 0.25%. Little actual use of this has been made in this country, since alloy steel makers decided that warehousing two grades, one non-leaded and one leaded, of all types of alloy steels in desired sizes would be too complicated.

Leaded steels for free machining have been marketed by most of the large steel companies in the United States, but it has generally been a high sulphur, high manganese grade with an addition of lead for further improvement in machinability. The added operations and care involved in adding lead have, however, made most of the steel makers cease to produce the leaded steels. Production of carbon and alloy leaded steels has, however, not been stopped in England but is being increased as a measure for more rapid production by the available machine tools. Manufacture could be resumed in the United States in the event of a severe shortage of manganese.

Titanium to Control Sulphur

Although titanium, like zirconium, does combine with sulphur in steel, under favorable circumstances, this fact does not necessarily mean that these elements have the same effect as does manganese in defeating the adverse effect of sulphur upon rollability and forgeability. Statements appear in the literature that titanium and zirconium do have this desirable effect, but examination of the way the tests were made raises doubt as to the correctness of the conclusions. No information is on record that would give a steel maker exact instructions as to how to use titanium for this purpose under conditions of regular, large-scale production. The conclusions based on tiny scale experiments may be entirely misleading. Yet the possibility that titanium may serve the purpose is not excluded. So only the Scotch verdict "not proven" can be given, pending adequate experiment, as far as the general substitutability is concerned.

There are large domestic deposits of titanium ores. The economic comparison of titanium with manganese from low grade domestic deposits does not appear favorable to titanium, but since the domestic manganese deposits are not inexhaustible, a technical evaluation of the applicability of titanium as a substitute, without regard to cost, seems to be in order. The use of ferrotitanium has been so limited that true quantity production has been out of the question. In really large scale production, the electric furnace manufacture of ferro-carbon-titanium should not entail double the conversion cost of SiO_2 to Si, so one would guess that the conversion cost need not be over 10¢ per lb. of contained titanium. Add another 10¢ for mining cost and these two major items should amount to not more than 20¢ per lb.*

Real applicability of titanium as a manganese substitute rests in the ability to use Fe-C-Ti, or some low carbon type, say Fe-Si-Ti, made in the electric furnace without having recourse to the low carbon Fe-Ti now made by aluminothermic methods. Because of the cost of aluminum for such reduction and the relatively small scale type of operation, this now carries a high price — $1.25 per lb. contained titanium.

Certain points are obvious in a consideration of the topic. Since titanium is a strong deoxidizer and is conducive to fine grain, only fine-grained killed steels, not rimmed, semi-killed or coarse-grained killed steels, can be made when it is used in sufficient amount to combine with sulphur. However, there are enough killed fine-grained steels produced so that measurable relief to the manganese situation might be had.

While substitution of titanium for manganese seems unpromising, its use in deoxidation and grain size control of steel makes it a substitute for aluminum in steel making and, in the present scarcity of aluminum, that factor might justify expansion of the production of Fe-C-Ti, Fe-Ti, and Fe-Si-Ti.

*Some authorities question this comparison, stating that a better comparison would be with low carbon ferrochromium, and suggest that 35¢ a pound would be a more reasonable figure. Also rising labor costs must be taken into consideration.

CRITICAL POINTS

By the Editor

TO THE $4,500,000 plant of Ohio Crankshaft, Inc., in Cleveland, newly opened after eight months of rapid construction, where 450 men and 314 precision machines are making nothing but crankshafts. Not all sorts of crankshafts, either. Just one design. For one aircraft engine. It's the Wright 14-cylinder 1700-hp. Cyclone motor for medium bombers. Here's specialization to the utmost. Also proof that the call for an air fleet of 50,000 planes was not just tall talk! ....The crankshaft has three major parts — the center section with the two cranks, the rear section driving auxiliaries and carrying the counterweights, and the front section for the propellers. These three chromium-nickel-molybdenum steel forgings weigh 268 lb., and it takes 445 operations to convert them into a finished heat treated assembly weighing 124 lb. Two counterweights and 25 fasteners and minor parts complete the unit, 206 lb. of flawless metal, with 100 dimensions gaged to 0.001 in. or better. .... Counterweights are loose, having 0.01 in. play, more or less, and guarded against sticking by bronze bushings and cheek plates. Probably the man who suggested this loose mass of metal on a madly spinning shaft was examined for his sanity — nevertheless it permits the counterweights to adjust their position automatically to correct for slight torsional unbalance, and does wonders in dampening the vibrations otherwise set up by rapid cylinder fire.

Crankshafts for a radial air-engine

DISCOVERED an interesting analogy between metallurgy and meat packing, for out at National Smelting Co. (Cleveland plant devoted to reclamation of secondary aluminum) "everything is saved but the squeal", thus: Turnings arrive by the carload, and are first degreased (oil recovered), chopped up for easier handling, and remelted under flux. Foundry drosses are screened to remove shot metal, tramp iron taken out on a magnetic conveyor — and sold — and the remaining metal melted in pots puddled to consolidate the liquid and cleanly separate the oxide. (Oxide, by the way, is in good demand by the chemical industry.) ...."Off-analysis" or mixed scrap is the common raw material. Aircraft companies, for instance, where much of the baled scrap now originates, can return some uncontaminated alloy 17 scrap to the original manufacturer to remake into 17S sheet, but most of the production divisions are unable to keep separate the four alloys they use so largely. Clean scrap whose nature is reasonably well known, therefore, is melted under flux in small gas-fired reverberateries (30,000-lb. capacity), rabbled well, quick analyses returned, correct additions made, and the charge cast into salable ingots on straight-line casting machines. Miscellaneous scrap is melted, analyzed, and pigged, later to be remelted in charges which can absorb its residual alloys safely. Aluminum "junk" — a word secondary smelters do not like — is ordinarily contaminated with iron, and is the origin of the 30,000 tons of metal used annually to quiet effervescent steel. This is sold to steel makers in four principal forms: Shot, granulated in water; corn-sized pellets, cast in a rotating wheel; small gear shapes, cast in permanent molds; and small notched ingots..... Surprising indeed was the extent of the air-conditioned research laboratory and its equipment, but not so surprising when one realizes that there is no commercial way to remove alloying metals, once they are in aluminum. National Smelting therefore early turned its attention toward finding successful uses for unconventional alloys. It has worked. Great amounts of alloy are sold for rotors for a.c. induction motors, and castability and electrical conductivity are the prime requirements of this metal. In this same research department is an experimental foundry complete with all testing equipment up to X-ray machines; it helps customers to develop correct technique for sound castings in sand, permanent molds, or dies.

Intelligent recovery of secondary aluminum

SUCCUMBED EVENTUALLY to internal urgings and repeated invitations to visit ROBERT HEATH, who studies metallurgical problems for Allison Engine Division of General Motors Corp. Procrastination was rewarded by an inspection of the new Indianapolis Plant 3, a cornfield 18 months ago, now a windowless, air-conditioned factory of most modern design and arrangement. The regularly spaced clusters of fluorescent tubes give a remarkably even illumination that doubtless is quite adequate, but also seems low in intensity when the glare of outside sunlight is glimpsed. . . . . An unusual number of finished parts are delivered by sub-contractors and other divisions of the Corporation, so size and quality inspection in the receiving department is most extensive. Noted some interesting, and somewhat unusual, devices and operations, such as an automatic feeder on a small magnaflux machine for 100% inspection of studs and bolts, and an electrical gadget which when passed along the stem of an exhaust valve indicates whether the required amount of sodium has been placed in the hollow bore. . . . . These valves illustrate why aircraft engines are so expensive. Made of high nickel-chromium austenitic steel, they have a stellite seat, nitrided stem sodium filled, and hardened carbon steel tappet-end, finished over-all most meticulously to a fraction of a thousandth. . . . . Bulk of the carburizing, hardening and annealing is done in row after row of good sized pit furnaces (electrically heated) of the "vapo-carb" and "homo" type. The heat treat has an airy cellar for all services and connections, and the furnaces are set on stilts so their tops are a couple of feet above the working floor level; they protrude through a steel-plate housing snugly enclosing a double line of them *en bloc*. A single jib can thus reach four covers; an overhead crane moves the work. Rather precise time-temperature control on carburizing, soaking periods for carbon diffusion, and controlled cooling are necessary to avoid excess carbides in the cases for parts such as S.A.E. 3312 gears, so high in alloy that the eutectoid contains only about 0.70% carbon. . . . . Surprisingly extensive and varied are the equipments for chemical treatments, a term which may be stretched to include all varieties of electroplating and deplating. Much copper plating is done prior to carburizing; stop-offs are of rubber accurately molded to fit the part exactly, and snap on and off quickly. Anodic treatment for aluminum, chemical treatments for paint bases, phosphate coatings on steel threads to prevent galling during tight assembly, and vacuum impregnating and baking furnaces for magnesium castings, run the gamut of modern surface treatments. . . . . Conversation could not help but turn to the relative merits of radial and in-line engines, air-cooled versus liquid cooled. BOB HEATH rested his case on the fact that the fastest one-man fighters and pursuit ships are powered by Allisons. But this is not merely another gas engine. Automobile engines, refined by 30 years of intense study, weigh about 6 lb. per hp.; Allisons weigh slightly less than 1 lb. This is achieved by using the maximum amount of aluminum and magnesium of minimum weight (regardless of cost) in the lightly loaded parts, and the minimum amount of strongest steel in the heavily loaded parts. Compare the connecting rods: In an automobile engine the rod requires 20 machine operations and 0.2 man-hour of labor; an Allison connecting rod requires 97 machine operations and 11 man-hours labor. It is machined all over, heat treated, polished free from tool marks, and finally shot blasted to put the surface in compression and so increase the endurance limit. . . . . Cheeks of crankshafts are also shot blasted for the same purpose. The work is done in a somewhat special shot blaster or "wheelabrator", wherein steel shot fly off at high velocity from a spinning wheel, then to strike the surface to be bombarded. The exact amount of surface work is checked at frequent intervals by sending through a piece of flat spring steel, rubber coated on one side. The amount of curvature it assumes is a measure of the compressive stresses locked up in the face exposed to the shower of steel projectiles.

Metallurgical practices at Allison air-engine plant

Shot blast increases endurance

AT BURBANK, California, the once peaceful domain of an agricultural wizard, now overrun by the aircraft industry, found VSEVOLOD (TEDDY) KRIVOBOK ensconsed as chief of a beautiful new structural research building and already — after a few months' exposure to whatever it is that makes them get that way — talking like a native son rather than a transplanted Pittsburgher. Some of his bright young men are doing important work on the flow of sheets in pressing. The basic idea is to lithograph a rectangular grid of fine lines 0.01 in. apart on one side of a sheet (on circular work, a polar grid), press or draw this prepared blank

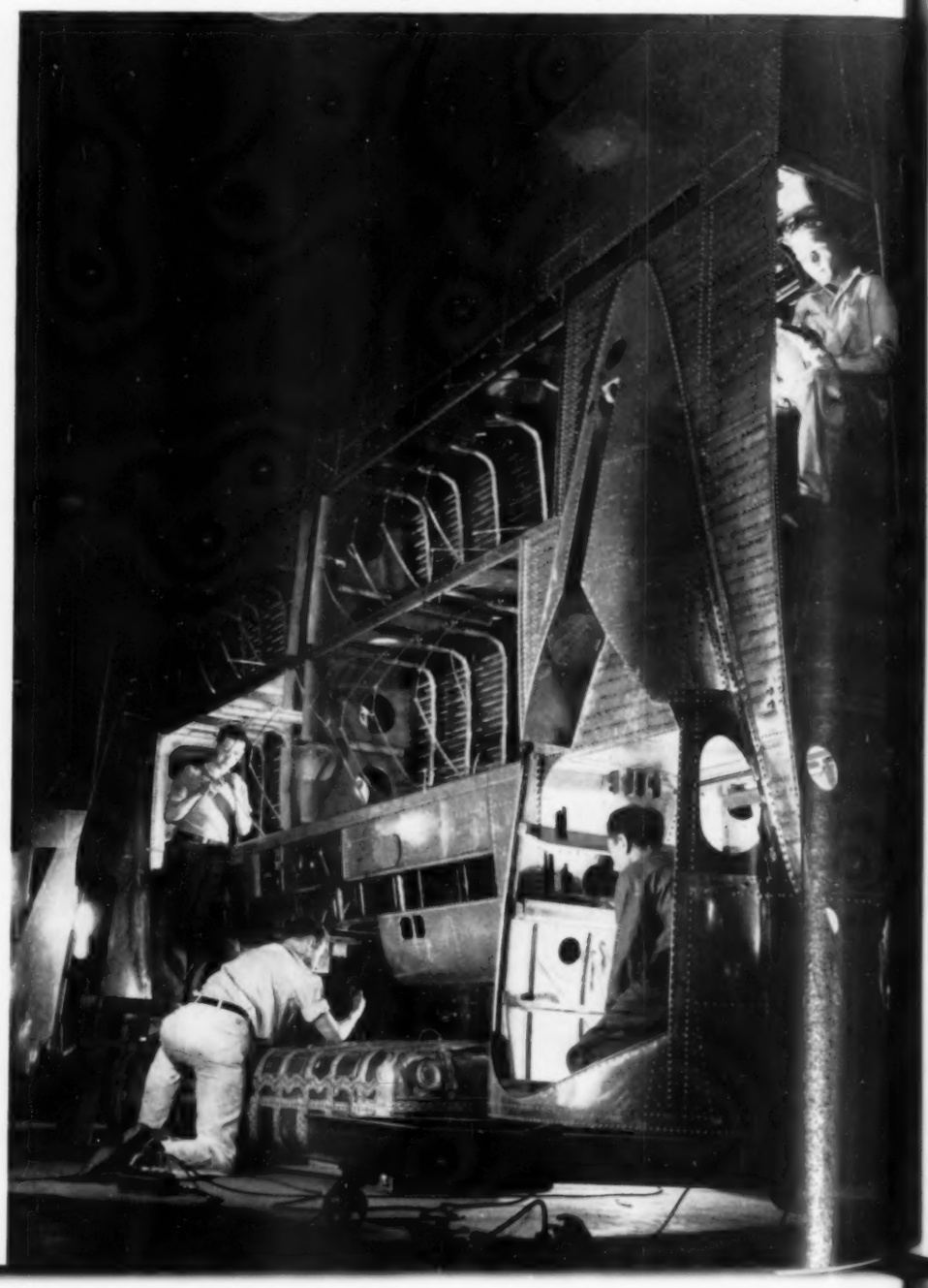
in a given set of dies, and measure the resulting changes in the sheet, point to point, under a micrometer microscope. Elongations have been recorded in tension of over 100% in 0.01 in. combined with compressive shortenings of over 50%. This in soft temper aluminum sheet that would show a maximum of 12% in 2 in. in an ordinary tension test. . . . . Naturally that's interesting, but based on such experimental data they are able to predict the susceptibility to various forming operations, to correlate minimum permissible bend radii with observed maximum allowable local elongations of the material, and to predict springback. Such knowledge about sheet metal flanges after being formed over blocks in the single-acting press by the GUERIN (rubber punch) process has extended it to aluminum alloys in the heat treated condition and eliminated troubles due to warping of a part formed of annealed material and subsequently heat treated. Over 800 parts formerly formed of SO material are now formed in the ST condition. Form blocks can now be built correctly without more than minor cut-and-try work at the start. . . . . Technique of drawing and stretching aluminum on the double-acting press, hitherto confined largely to mild steel parts in the automotive industry, is also under study. Many parts are now being formed on the drop hammers, which could be produced much faster and more economically on double-acting presses. When this can be done it will avoid a lot of hand straightening, unwrinkling and trimming.

Fundamental work on the drawability of aluminum

REMINDED that in the 1934 Campbell Memorial Lecture Dr. KRIVOBOK expounded the function of nitrogen in the stainless steels, and how it had many of the characteristics of carbon as a hardener and strengthener. Unless memory is again playing tricks (time does fly so!) mention was also made of the similar possibilities of boron. Seven years later, in the 1941 search for something to make nickel steel out of other than nickel, boron again bobs up as one of those powerful elements that do remarkable things to steel even though present in sub-analytical amounts. M. J. R. MORRIS, metallurgist of Republic's alloy steel division, told me of one 1040 steel with 0.003% boron (or so the spectroscopist said) that heat treated to 255,000 psi., 11% elongation in 2 in., and 43%

Boron for a steel hardener

They Make These Wing and Engine Sections Pretty Big for a Long Range Bomber. Photo by Lawrence Kronquist for Douglas Aircraft Co.



reduction of area in the standard 0.505-in. test piece. Pretty good for a plain carbon steel, treated with about 1 lb. of dehydrated borax per ton. Control of such minuscule additions is bound to be tricky and cause a lot of trouble before it is adequately done, and since now is no time for experimental heats, will probably be another development for the post-Hitler era . . . This boron apparently is an elusive something. WALTER HIRSCH told me in Los Angeles that the 4% nickel, 1% boron, wear resistant white iron called "X-aloy" or "I. R. Metal" and used for many pump liners was studied by several important steel companies and machinery manufacturers when considering patent licenses and none discovered "X", the boron that makes the iron white. (He was with Industrial Research Laboratories of Los Angeles, and was responsible for the development.) It all came from the fact that assays of numerous iron-bearing ores in Southern California gave iron buttons of peculiar properties. The iron turned out to be nothing special, merely Fe (ferrum), but the fire assay was made with generous amounts of borax flux and fine charcoal (or in a graphite crucible), so enough boron entered the regulus to harden it excessively. . . . . A final note: Boron is now an accepted minor addition to some special molybdenum high speed steels —its function being to increase the hardenability and decrease surface decarb.

FOUND that oil refinery men are much interested in strategic metals, for they have already had difficulty in getting a steady supply of brass condenser tubes for the heat interchangers and coolers. K. V. KING, materials engineer of Standard Oil Co. of California, said that his firm has been salvaging 18-8 chromium-nickel tubes, taken out of oil stills after ten years of service, worn by soot cleaners rather than corrosion, and is using them for substitutes for brass in interchangers. He believes the more expensive 18% chromium, 8% nickel tubes are usually more economical for new stills than the cheaper 5% chromium tubes, for the latter have a thicker wall and lower heat transfer. Likewise if temperatures are adequately controlled and hot spots from flame impingement avoided, low carbon 18-8 is practically indestructible when handling California crudes . . . One noticeable trend in refinery practice is toward higher temperature rather than higher pressures in the new cracking stills; the 0.08% max. carbon, 12.5% chromium steel with 0.20% aluminum (A.I.S.I. type 405) serves excellently here, and is especially adaptable for safe welding with the atomic hydrogen process.

Stainless tubes in California oil refineries

COMES NOW a friendly admonition from a member of U. S. Navy's Bureau of Ships — the boys who construct and repair them — about the Editor's plea for the purchase of steel by desired properties rather than by chemical composition. The concluding sentences on page 304 of the September issue implied that the Navy (among other government agencies and large civilian industries) was insisting on expensive steels when lower alloys would do the work. As a matter of fact, the Navy has always specified carbon and low alloy steels by the tensile and bend properties desired, rather than by composition. Even guns and armor and big shafting and hull forgings are anything that will pass the physical tests specified; they may be heat treated in any way the manufacturer desires. Specifications which mention alloying elements like chromium would read zero to 3%, obviously a mother hubbard. . . . Specifications for steel plates, shapes and castings for hull construction covering 90% of the tonnage requirements other than pipe, specify maxima in carbon, sulphur and phosphorus, and no limits on any other element. Only where special properties are required is this situation changed. Two instances: Chromium-nickel stainless steels; manganese-vanadium steel plates, shapes and castings which are to be welded. . . . My informant says that contractors who have furnished materials to the Navy in past years generally appreciate this wide latitude in choice of materials and treatments, and have each worked out economical procedures for the individual shops. On the other hand, new contractors are continually importuning the naval inspectors and engineers to specify some S.A.E. or A.I.S.I. steel analysis that will meet the required tensile, bend, nick-break, and microstructural limits, either in the raw state or after a simple heat treatment. . . . There is an undesirable reluctance on the fabricators' part to make preliminary tests to verify whether such and such an available steel will be suitable. More unfortunate is the apparent reluctance to solve the metallurgical problem for themselves.

The Navy buys properties in steel rather than analysis

LETTERS FROM

HOME AND ABROAD

INTERCONVERSION CHART ATOMIC TO WEIGHT PER CENT

MINNEAPOLIS, MINN.

To the Readers of METAL PROGRESS:

In industrial and scholastic research the need frequently arises for conversion from atomic to weight per cent, or vice versa. Continental publications often plot constitution diagrams, or express alloy compositions, in atomic per cent; such procedure serves a specific purpose, but it confuses our normal concept of compositions in terms of relative weights. Metallurgists more often require the conversion from weight per cent to atomic per cent for such a purpose as the location of compound lines in constitution diagrams.

The calculations involved for either conversion are simple:

If x = weight per cent

and y = atomic per cent of an element of atomic weight A,

Then (100 — x) = weight per cent

and (100 — y) = atomic per cent of the element of atomic weight B in any binary compound.

It follows by simple arithmetic that the atomic per cent y is

$$y = 100\,\frac{\frac{x}{A}}{\frac{x}{A}+\frac{100-x}{B}} = \frac{100x}{x+\frac{A}{B}(100-x)}$$

and the weight per cent x is,

$$x = 100\,\frac{yA}{yA+(100-y)B} = \frac{100y}{y+\frac{B}{A}(100-y)}$$

In an attempt to reduce the time involved in tedious mathematical conversions, various methods have been proposed. The mathematical conversions for binary and ternary systems and the relative merits of each scale, atomic and weight per cent, were discussed by FRITZ HOFFMAN and by ERNST JANECKE in *Metallurgie* in 1912. They presented rather involved graphical conversion methods for both systems. Redlich in *Zeitschrift anorg. allgem. Chemie* (1928) devised a method for constructing a complicated nomograph for ternary conversion, but it is impractical. Various graphical conversions for ternary compounds were devised by WILLIAM HUME-ROTHERY in the *Journal* of the British Institute of Metals in 1933, and by CYRIL S. SMITH in Paper No. 60 (1933) for the A.I.M.E.

We are here concerned with the interconversion of binary alloys. HERBERT WATERMAN (*Industrial and Engineering Chemistry*, 1931) and TEMPLE C. PATTON (*Chemical & Metallurgical Engineering*, 1934) developed nomograms for the job which are simple to construct and operate, and they apply to all binary systems. HERMANN, in *Metallwirtschaft*, 1933, illustrated a slide rule for the purpose, and CYRIL S. SMITH offered some special log tables for making quick, accurate conversions, in his paper before the A.I.M.E.

The interconversion chart developed by the writer and shown on pages 900 and 901 is for quick conversions of binary compounds where accuracy to the nearest 1% is sufficient. The method of its use eliminates the necessity of graphical construction, making mathematical calculations on the side, or the drawing of any lines. Where accuracy to the second decimal place in the per cent value is required, the log tables of SMITH will give good results, but, for most uses, this new chart is very fast and gives sufficient accuracy.

RAY P. DUNN
Metallurgist
Electro Manganese Corp.

MASTER CRAFTSMEN

Grinling Gibbons, famed wood carver of the fifteenth century, decorated with fine carvings many of the great churches and palatial buildings of old London.

Wood carving or pattern making, each is an art closely related in principle. The value of each is based on the purpose it is to serve.

In plants where patterns are used, the craftsman selects his wood, regardless of cost, that is best fitted for the job at hand.

Grinling Gibbons

THERMALLOY *the "EYE" of QUALITY*

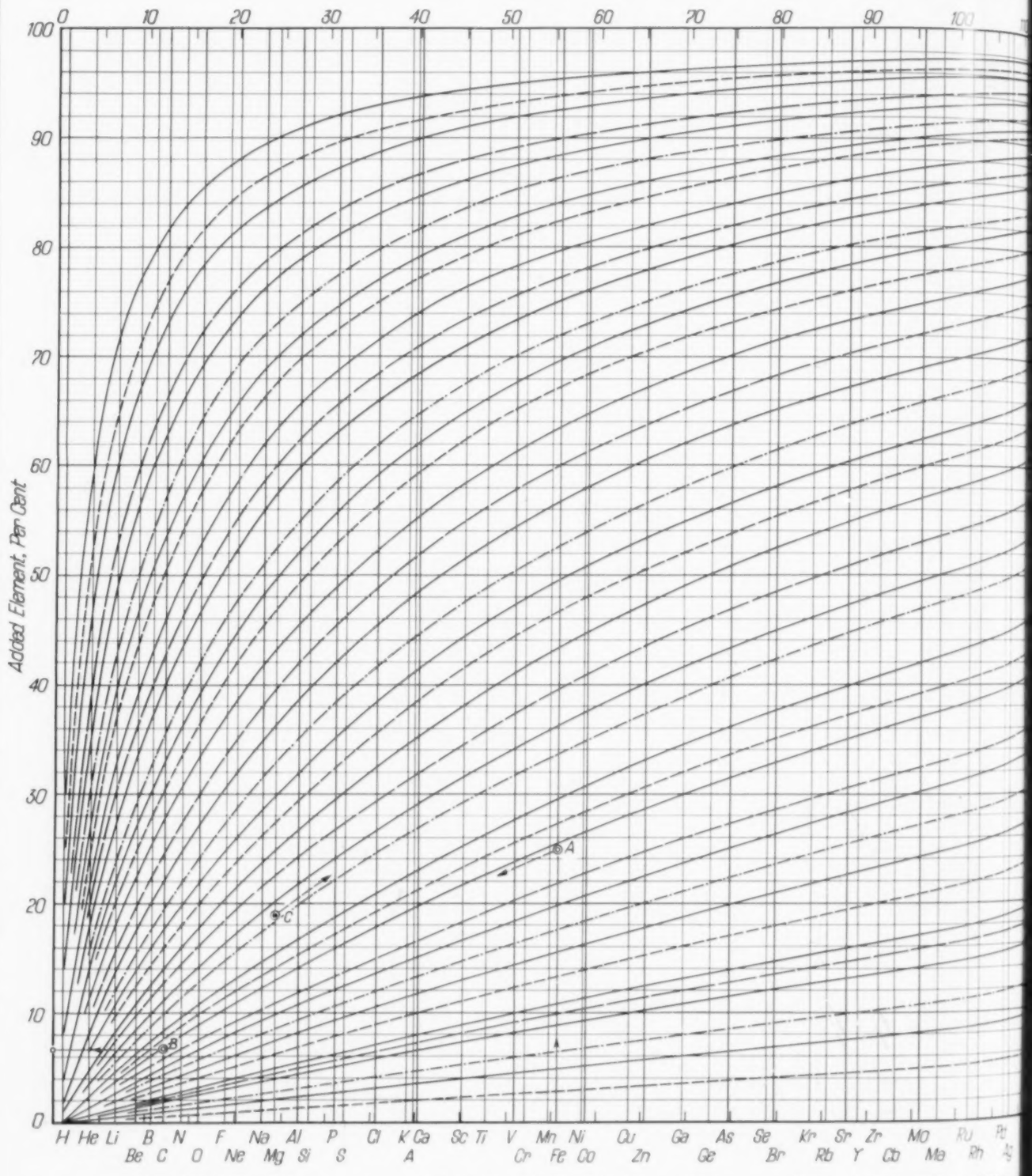
THE ELECTRO ALLOYS COMPANY

CASTINGS FOR HEAT CORROSION

ELYRIA, OHIO

QUALITY CASTINGS SINCE 1915

Interconversion Chart,


0 10 20 30 40 50 60 70 80 90 100
100 90 80 70 60 50 40 30 20 10 0
Added Element, Per Cent
A
B
C
H He Li Be B C N O F Ne Na Mg Al Si P S Cl A K Ca Sc Ti V Cr Mn Fe Ni Co Cu Zn Ga Ge As Se Br Kr Rb Sr Y Zr Cb Mo Ma Ru Rh

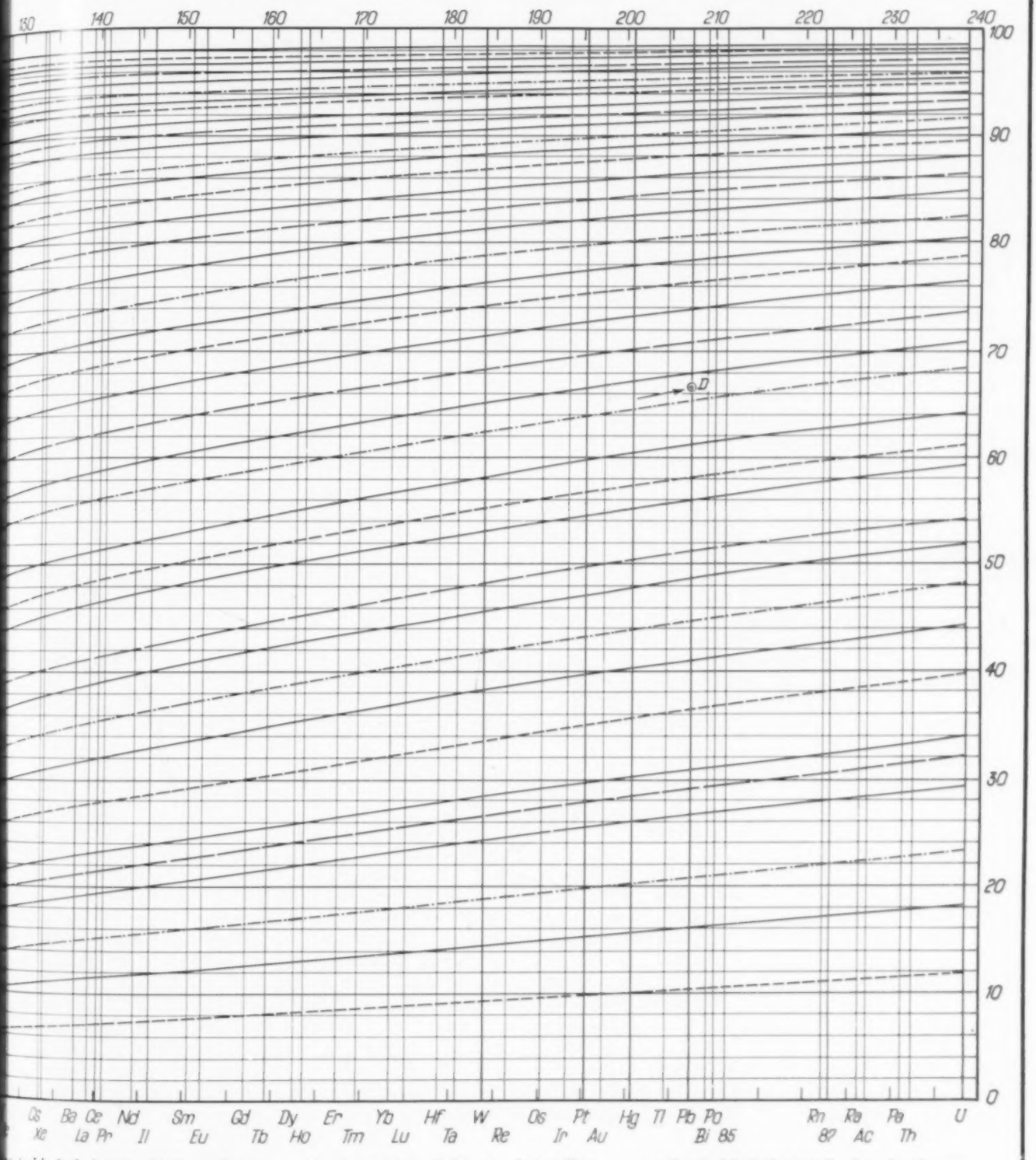
Explanatory Notes

EXAMPLE 1. To change atomic % to weight %: Fe.C contains 25 atomic % carbon (added element). Locate *A*, at 25% on the vertical line of iron (atomic weight of base element). Select curve through this point, or note its relative position between neighboring curves, and follow along the curve until it intersects the vertical atomic weight line of carbon (added element) at *B*. The horizontal through this intersection gives about 6.7 weight % carbon. Actual value: 6.67% [illegible] bon by weight.

EXAMPLE 2. To change wei[illegible] % to atomic %: In the Pb-Mg s[illegible] tem a compound occurs at [illegible] weight % Mg (added elemen[illegible] Locate *C*, at 19% on the magnesi[illegible]

t, ...e and Weight Per Cent

Devised by Ray P. Dunn



...e (added element). Follow along ...ween curves to the lead vertical ...se element). The horizontal ...ough this intersection at *D* gives ... atomic % Mg (actually 66.67%).

CAUTION: The "Per Cent Added ...ement" scale applies for both the atomic and weight % depending upon the conversion. The key to correct usage is to locate weight % on the atomic weight line of *added* element, and atomic % on weight line of *base* element. Either element of a binary may be chosen as the "added element"; thus in the Pb-Mg system, Pb may be the "base element" and Mg the "added element", as considered above, or magnesium may be considered the "base element" with lead as the "added element".

★ ★ ★

NICKEL

Practical answers to many questions about the selection, fabrication and uses of Nickel alloys are quickly available to you. This helpful information we have gathered, checked and condensed into convenient printed form. It is useful both to experienced men handling new materials or performing unfamiliar operations... and to new employees. This literature is available upon request. You are also offered the assistance of our technical staff in solving material problems arising from a temporary lack of Nickel. Our engineers are offering timely suggestions to many vital industries during the present emergency. Your request for literature or personal consultation will receive our prompt attention.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

CALCIUM— ITS EFFECT ON ALUMINUM

NEW KENSINGTON, PA.

To the Readers of METAL PROGRESS:

In a note by CHARLES HARDY published in the July 1941 issue on page 70, it was recommended that metallic calcium be utilized in the remelting of aluminum scrap for the removal of tin, bismuth, silicon, antimony and lead alloyed with it. We cannot second this recommendation.

The results of tests available at the Aluminum Research Laboratories show no reduction in small quantities of tin, lead, antimony or bismuth added to aluminum and then treated by additions of 0.10% or 0.20% calcium. In another test, 1% calcium was added to aluminum containing 0.15% lead and after the treatment the lead content was found to be unchanged.

In addition, it has been demonstrated that the presence of calcium in aluminum alloys containing copper causes a definite lowering of strength in the solution heat treated temper. For example, the addition of 0.05% calcium to No. 195 alloy lowered the tensile strength from 33,000 psi. to 27,000 psi. A similar effect was obtained in duralumin-type (17S-T) sheet having a tensile strength of 62,000 psi., which was lowered to 59,000 psi. by the presence of 0.19% calcium and further to 54,000 psi. by the addition of 0.36% calcium.

It is suggested that these results should be given consideration by anyone who is contemplating treating aluminum with calcium.

PHILIP T. STROUP
Research Metallurgist
Aluminum Co. of America

ZINC BASE DIE CASTING ALLOYS WITH LOWERED ALUMINUM

CHICAGO, ILL.

To the Readers of METAL PROGRESS:

Under the sponsorship of American Society for Testing Materials, Sub-Committee II of Committee B-6 on Die Cast Metals and Alloys, a series of investigations has been under way looking toward the possible reduction in aluminum content in the widely used zinc-base alloys No. XXIII and XXV (A.S.T.M. specifications B86 — 38T). Before recommending any definite steps in the conservation of this strategic metal aluminum, the committee felt some positive tests should be made to answer questions concerning possible manufacturing difficulties which may be encountered relating to hot-shortness, shrinkage, freezing range, surface appearance and casting characteristics of the lower aluminum alloys.

These two zinc alloys are the ones most commonly used in the die casting trade today. Alloy XXIII is a zinc-base alloy containing 4% aluminum and about 0.03% magnesium. Alloy XXV differs by the inclusion of 1% copper. Both alloys are compounded with special high grade zinc (99.99%).

The eutectic in the zinc-aluminum system occurs at about 5% aluminum. Alloys containing 4% are therefore close to the eutectic composition and have a short freezing range. As a result, they possess a minimum of casting difficulties, and the adoption of this aluminum content in the development of these alloys was based largely on the good casting properties coupled with what appeared to be the optimum combination of physical properties.

These standard alloys have been in commercial use for over 10 years with satisfactory service records. Now, because of the aluminum shortage, the possibility of using alloys with less than 4% aluminum is being investigated. Preliminary results based on laboratory tests are now available and some conflicting commercial experience has been reported in their use.

With respect to laboratory tests, Apex Smelting Co. has reported a considerable amount of data, from which is taken the following comparison of these two alloys, both as cast and after the "steam test" (10 days in water vapor at 95° C.):

	AL	CU	MG
A.S.T.M. Alloy No. XXV	4.1%	1.0%	0.03%
Low aluminum substitute	1.5	1.0	0.03

	ALLOY No. XXV	SUBSTITUTE ALLOY
Tensile strength, as cast ...	44,300 psi.	40,400 psi.
Tensile strength, steam test	34,500	28,000
Elongation, as cast	5.3%	5.7%
Elongation, steam test	3.7	5.7
Charpy impact,★ as cast ..	38.5 ft-lb.	34.0 ft-lb.
Charpy impact,★ steam test	6.7	12.8
Dimensional change on 6-in. bar, after steam test	—0.0002 in.	—0.0006 in.

★Average of gate and vent.

New Jersey Zinc Co. reports that as far as its tests have gone, they substantially check the above, except in respect to dimensional change. Known slight differences in analysis and possible differences in *(Continued on page 978)*

Designations for Heat and Corrosion Resistant Alloys

New York City

To the Readers of Metal Progress:

A standard system of designation for high nickel-chromium and straight chromium alloys used in heat and corrosion resistant castings has been adopted by the members of the Alloy Casting Institute. They cover the particular composition ranges most suitable for castings and were chosen to distinguish these *cast* alloys from those customarily used in wrought form.

It is believed that general use of standard designations will help to clarify the present confusing situation which confronts many buyers of heat and corrosion resistant material. This confusion has resulted largely from the number of different names and symbols which have grown up around the various alloy compositions loosely referred to as "stainless steels".

Several years ago a series of type numbers was developed by the American Iron & Steel Institute to simplify the designations of wrought stainless steels, and these numbers have since received wide recognition. Unfortunately, however, composition ranges satisfactory for rolled products often are not desirable for castings. Many alloy compositions not practicable to produce in wrought form are of considerable value when produced in cast form. For this reason the purchaser who orders castings by a wrought alloy type number may receive articles less suited to his requirement than had he chosen an alloy specifically designed for castings.

It is believed that the system of designation provides a concise description of a specific alloy composition, and at the same time is sufficiently flexible to allow for future additions. All designations begin either with the letter *C* or *H*, indicating that the alloy is corrosion resistant or heat resistant respectively. The second letter of the symbol arbitrarily represents the nickel and chromium ranges, the nickel percentages increasing in amount from *A* to *Z*. In the case of corrosion resistant alloys a number follows the first two letters and represents the maximum carbon content in hundredths of one per cent. These numbers are omitted in the general designations of heat resistant compositions; in them carbon may be indicated if

Designations of Type Compositions for Heat and Corrosion Resistant Castings

(Alloy Casting Institute, 1941)

Designation *(a)*	% Nickel	% Chromium	% Carbon	% Other Elements *(b)*
CA-14	1 max.	11 to 14	0.14 max.	—
CA-40	1 max.	11 to 14	0.20 to 0.40	—
CB-30	2 max.	18 to 22	0.30 max.	—
CC-35	3 max.	27 to 30	0.35 max.	—
CD-10M	3 to 6	27 to 30	0.10 max.	Molybdenum 2.00 max.
CE-30	8 to 11	27 to 30	0.30 max.	—
CF-7	8 to 10	18 to 20	0.07 max.	—
CF-10	8 to 10	18 to 20	0.10 max.	—
CF-16	8 to 10	18 to 20	0.16 max.	—
CF-20	8 to 10	18 to 20	0.20 max.	—
CF-7Se	8 to 10	18 to 20	0.07 max.	Selenium 0.20 to 0.35
CF-7C	8 to 10	18 to 20	0.07 max.	Columbium 10×Carbon
CF-7M	8 to 10	18 to 20	0.07 max.	Molybdenum 2.5 to 3.5
CF-10M	8 to 10	18 to 20	0.10 max.	Molybdenum 2.5 to 3.5
CF-16M	8 to 10	18 to 20	0.16 max.	Molybdenum 2.5 to 3.5
CF-7MC	8 to 10	18 to 20	0.07 max.	Molybdenum 2.5 to 3.5; Columbium 10×Carbon
CG-7	10 to 12	20 to 22	0.07 max.	—
CG-10	10 to 12	20 to 22	0.10 max.	—
CG-16	10 to 12	20 to 22	0.16 max.	—
CG-16Se	10 to 12	20 to 22	0.16 max.	Selenium 0.20 to 0.35
CG-7C	10 to 12	20 to 22	0.07 max.	Columbium 10×Carbon
CG-7M	10 to 12	20 to 22	0.07 max.	Molybdenum 2.5 to 3.5
CG-10M	10 to 12	20 to 22	0.10 max.	Molybdenum 2.5 to 3.5
CG-16M	10 to 12	20 to 22	0.16 max.	Molybdenum 2.5 to 3.5
CG-7MC	10 to 12	20 to 22	0.07 max.	Molybdenum 2.5 to 3.5; Columbium 10×Carbon
CH-10	10 to 12	23 to 26	0.10 max.	—
CH-20	10 to 12	23 to 26	0.20 max.	—
CH-10C	10 to 12	23 to 26	0.10 max.	Columbium 10×Carbon
CH-10M	10 to 12	23 to 26	0.10 max.	Molybdenum 2.5 to 3.5
CH-10MC	10 to 12	23 to 26	0.10 max.	Molybdenum 2.5 to 3.5; Columbium 10×Carbon
CH-20M	10 to 12	23 to 26	0.20 max.	Molybdenum 2.5 to 3.5
CK-25	19 to 21	23 to 26	0.25 max.	—
CM-25	19 to 22	8 to 11	0.25 max.	—
HB	2 max.	18 to 22	*(b)*	—
HC	3 max.	27 to 30	*(b)*	—
HD	3 to 6	27 to 30	*(b)*	—
HE	8 to 11	27 to 30	*(b)*	—
HH	10 to 13	23 to 27	*(b)*	—
HK	19 to 21	23 to 26	*(b)*	—
HL	19 to 21	28 to 32	*(b)*	—
HP	29 to 31	28 to 32	*(b)*	—
HS	29 to 32	8 to 12	*(b)*	—
HT	34 to 37	13 to 17	*(b)*	—
HU	37 to 40	17 to 21	*(b)*	—
HW	59 to 62	10 to 14	*(b)*	—
HX	65 to 68	15 to 19	*(b)*	—

(a) Designations with the initial letter "C" indicate alloys generally used to resist corrosive attack at temperatures less than 1200° F. Designations with the initial letter "H" indicate alloys generally used under conditions where the metal temperature is in excess of 1200° F.

(b) No attempt is made to cover elements such as manganese, silicon and, in the case of heat resistant alloys, carbon.

desired, by adding a number to the symbol to represent the middle of a ten-point carbon range. If special alloys are also included in the composition they are indicated by the addition of a letter or letters to the symbol. For example: CF-7MC represents a corrosion resistant alloy of 8% to 10% nickel, 18% to 20% chromium, with 0.07% carbon max. and with molybdenum and columbium additions.

The accompanying table sets forth the list of general designations covering those alloys in greatest use at the present time. Composition ranges are specified for nickel, chromium and other elements, but it is not intended that the designations should represent precise chemical specifications. Elements such as manganese, silicon and, in the case of heat resistant alloys, carbon have not been covered.

It is not anticipated that alloy casting producers will discontinue the use of their established trade names for these alloys, but the new designations can be used by purchasers in specifying the alloys they desire. In addition, by providing a uniform nomenclature, these symbols will facilitate the development of specifications by the Technical Research Committee of the Alloy Casting Institute and by other interested technical societies.

E. A. SCHOEFER
Executive Secretary
Alloy Casting Institute

ORIGINALIS FERRITIS

Above is a photomicrograph of *Originalis Ferritis*, an extremely rare species of icy-brine fish. He is seeking refuge from the many rabid anglers who ply the waters of Austenite Lake.

N. C. FICK
Research Laboratory
United States Steel Corp.

THE SOLIDUS IN THE IRON-GRAPHITE SYSTEM

BERKELEY, CALIF.

To the Readers of METAL PROGRESS:

The otherwise excellent iron, iron carbide diagram printed on page 511 of the October, 1941, issue of METAL PROGRESS contains an error in fundamental principles which I believe worthy of mention. This refers only to the red lines of the iron-graphite equilibria.

In a phase diagram all the boundary lines indicate conditions under which *equilibrium* sets in between two phases. Thus the solidus line *JE* indicates the temperatures and compositions at which austenite begins to melt, and the liquidus line *BC* indicates where the melting is completed. The positions of both lines are determined by the reversible reaction

$$\text{austenite} \rightleftarrows \text{melt}$$

and depend in no way on whether graphite or cementite will later be precipitated. Hence the solidus *JE* of the iron, iron carbide diagram must coincide with the solidus *JE′* of the iron-graphite system. The red solidus line to *E′* printed on the diagram in METAL PROGRESS and the black solidus *JE* should not be separated. For the same reason the point C′ should lie on the curve BC (and apparently does when the registry of the printing is accurate).

The other red lines properly belong on the diagram, since they represent reversible reactions in which graphite or cementite is concerned.

The equilibrium diagram as it appears in EPSTEIN's book on "Alloys of Iron and Carbon", page 157, is correctly drawn.

RALPH HULTGREN
Assistant Professor of Physical Metallurgy
University of California

EDITOR'S NOTE: A footnote to the diagram in question gives the authority for line *JE′* as HARRY A. SCHWARTZ, the erudite manager of research for National Malleable & Steel Castings Co., and a lifetime student of the graphitization of white iron. Dr. SCHWARTZ forwards this comment in reply to the points raised by Prof. HULTGREN:

The comment of Professor HULTGREN with respect to the iron-carbon diagram would be acceptable without further discussion if it were known that all the solid solutions of iron and carbon were identical, *(Continued on page 974)*

Since chromium and nickel, especially the latter, are critical metals to be reserved for such purposes as they alone can serve by reason of their unique properties, it is important to find an alternate alloying element to provide their hardening power in steels. By doubling the manganese and molybdenum and leaving out the chromium and nickel, steels comparable in hardenability to the S.A.E. 4100 and 4300 series are produced.

NEW DATA FOR EVALUATING MANGANESE-MOLYBDENUM STEELS

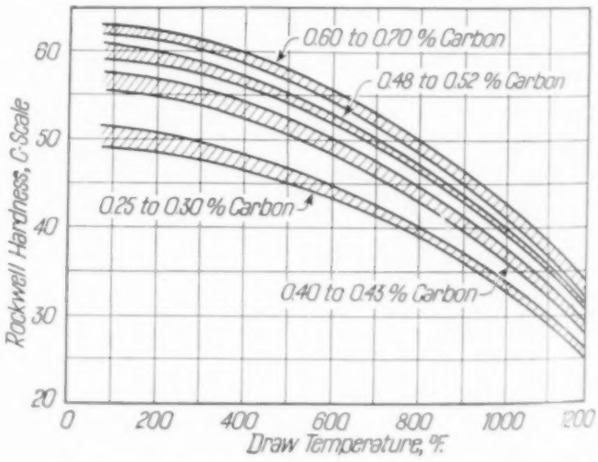
By ROBERT M. PARKE, JAMES R. BLANCHARD, and ALVIN J. HERZIG
Members of the Research Department, Climax Molybdenum Co. of Michigan, Detroit

SINCE the present shortage of most of the common alloying elements for steel has become acute, more and more attention has been directed to the properties obtainable from a combination of carbon, manganese, and molybdenum. Metallurgists are aware of the emphasis placed today on the use of manganese plus molybdenum as a means of promoting hardenability in steel.

Manganese-molybdenum steels are certainly not new; even prior to the present emergency they were being produced in appreciable tonnages for special applications. These special uses, however, have not provided us with information bearing directly on the requirements for which manganese-molybdenum steels are now proposed. For example, hardenability of these steels received attention principally in connection with the properties found on normalizing or on welding. The more informative data derivable from end-quench hardenability tests, hardness vs. tempering temperature curves, and studies of rates of isothermal decomposition of austenite are exceedingly sparse.

It is this latter type of information which the metallurgist has lately learned to depend on for the selection and use of alloy steels. Therefore, it seems appropriate to examine manganese-molybdenum steels from the new point of view. This article presents very briefly some new data along these lines, for evaluating steels having manganese and molybdenum contents near the maximum likely to find commercial use during the present emergency.

The steels were prepared for this investiga-

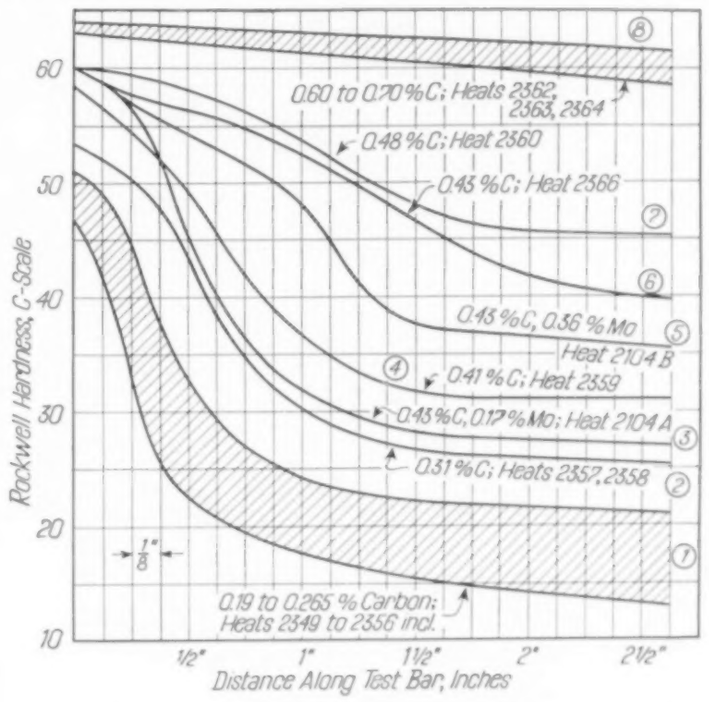


Hardness Versus Draw Temperature Relationships for Four Ranges of Carbon Contents in Steels Containing About 1.50% Mn and 0.40% Mo

tion from 30-lb. melts made in a high frequency induction furnace. The steels were deoxidized with 0.08% aluminum. Their compositions, grain sizes, equilibrium critical temperatures, and quenching temperatures are listed in the adjoining table.

Hardness versus tempering temperature data for ten of the steels are shown in the first small diagram, wherein the shaded areas contain the hardnesses for the groups of steels which lie in the designated ranges of carbon content.

Hardenability curves obtained from the JOMINY end-quench test are shown in the second diagram. The hatched regions in this figure include the entire range of hardness produced by the group of steels described therein. The effect of increasing molybdenum from 0.17 to 0.36% on the hardenability of a 0.43% carbon, 1.7% manganese steel may be seen by comparing curves No. 3 and 5. A comparison of curves No. 5 and 6 with the end-quench hardenability curves of other alloy steels containing 0.40% carbon, as given by JOMINY in his article on "Hardenability Tests" in the ASM book, "Hardenability of Alloy Steels", will show that this manganese-molybdenum steel has a hardenability which lies between that of S.A.E. 4140 (Cr-Mo) and S.A.E. 4340 (Ni-Cr-Mo).



End-Quench Hardenability Test of C-Mn-Mo Steels

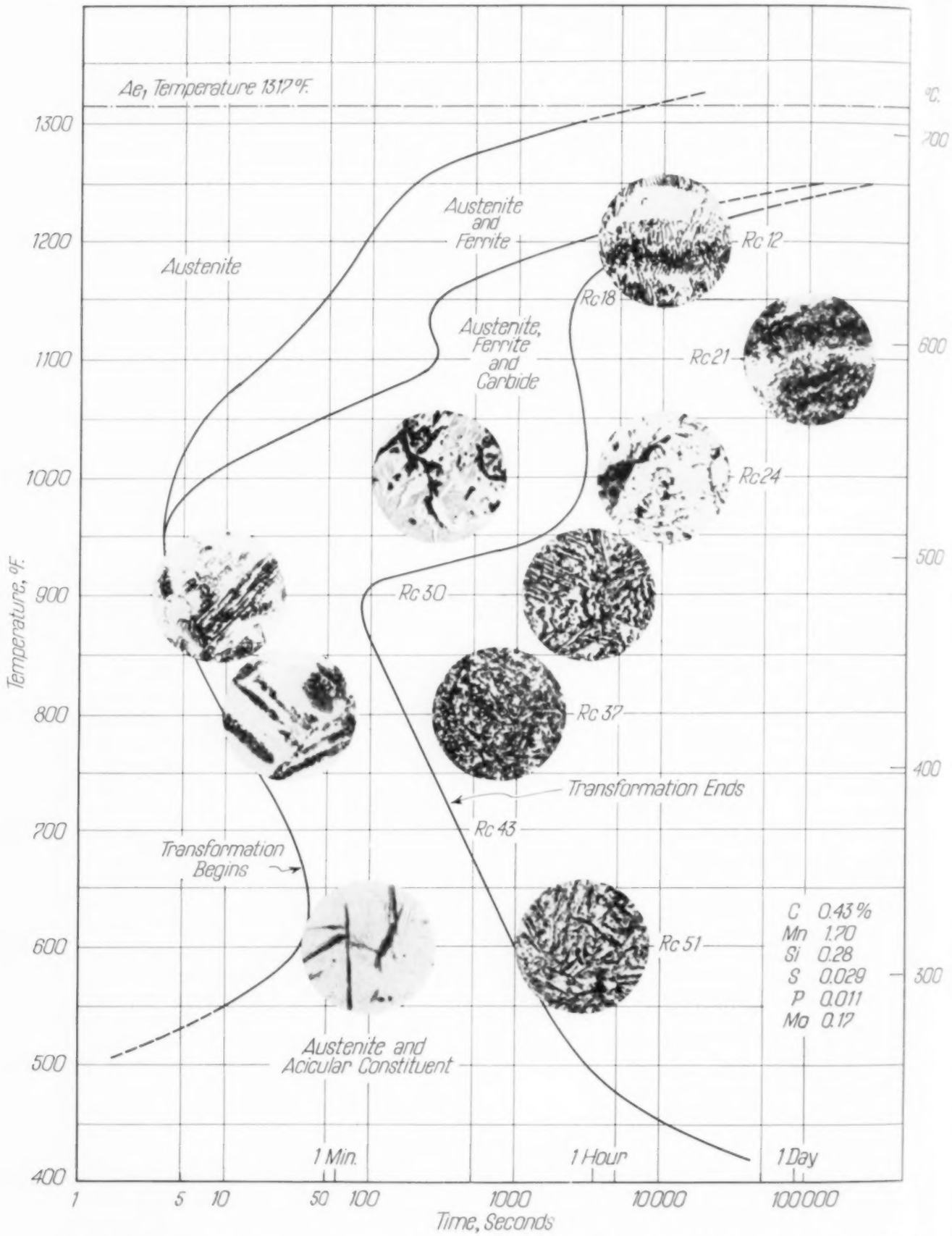
Hardnesses developed by a steel, when that steel is austenitized and cooled at certain rates, may be determined from this end-quench hardenability test. From the hardness versus tempering temperature curve we obtain qualitative data on the rate of softening by spheroidizing. Still, we cannot predict from these tests alone (as completely as is desired) the behavior of a steel in commercial processing. If the use of large tonnages of manganese-molybdenum steels is contemplated, it is important to secure, in a minimum of time, assurance that the proposed combination of alloying elements will not lead us into complex fabricating and heat treating processes.

The one remaining tool, available to the laboratory, that assists in the appraisal of a

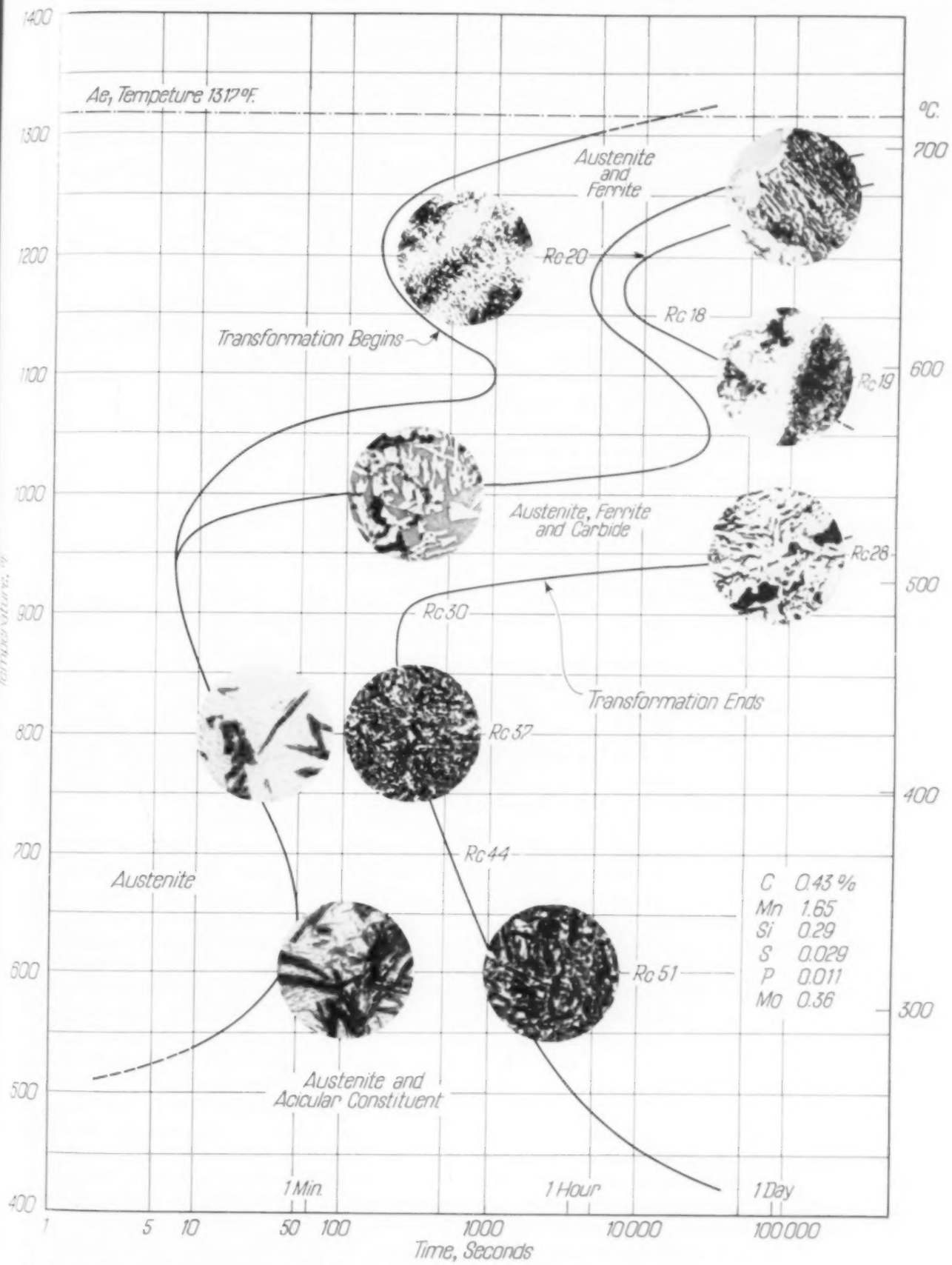
Analyses of the Test Ingots

Heat No.	Chemistry				Critical Points		A.S.T.M. Grain Size	Quench Temperature
	C	Mn	Si	Mo	Ae_1 (°F.)	Ae_3 (°F.)		
2349	0.22	1.58	0.30	0.31			6 to 8	1600° F.
2350	0.245	1.52	0.27	0.30			6 to 7	1600
2351	0.26	1.59	0.32	0.29			7 to 8	1600
2356	0.20	1.54	0.26	0.28			6 to 7	1600
2352	0.19	1.41	0.30	0.39			6 to 7	1600
2353	0.225	1.33	0.30	0.39	1339° F.	1535° F.	6 to 8	1600
2354	0.265	1.51	0.26	0.38			7 to 8	1600
2355	0.255	1.52	0.30	0.39			7 to 8	1600
2357	0.295	1.52	0.29	0.39	1335	1499	7 to 8	1575
2358	0.32	1.58	0.30	0.39			6 to 7	1575
2359	0.41	1.42	0.31	0.39			7 to 9	1525
2360	0.485	1.61	0.32	0.41			5 to 8	1500
2361	0.53	1.61	0.32	0.41			5 to 7	1500
2366	0.43	1.60	0.31	0.37	1328	1445	7 to 8	1525
2104A	0.43	1.70	0.28	0.17	1317 *(a)*		7 to 8 *(b)*	1550
2104B	0.43	1.65	0.29	0.36	1317 *(a)*		8 *(b)*	1550
2362	0.65	1.65	0.30	0.39	1342	1375	6 to 8	1475
2363	0.595	1.61	0.33	0.39			6 to 7	1500
2364	0.695	1.64	0.31	0.38			5 to 7	1475

(a) Critical points determined metallographically (others dilatometrically).
(b) Austenitic grain size at 1550° F. (others McQuaid-Ehn at 1700° F.).



Isothermal Transformation ("S" Curves) of 0.43% Carbon, 1.70% Manganese Steel Containing 0.17% Molybdenum. Austenitizing temperature: 1550° F. Austenite grain size: 7 to 8. Micros at 1000 dia.



Isothermal Transformation ("S" Curves) of 0.43% Carbon, 1.65% Manganese Steel Containing 0.36% Molybdenum. Austenitizing temperature: 1550° F. Austenite grain size: 8. Micrographs at 1000 dia.

steel is the "S" curve. Such curves for two of the steels (Heats 4104A and 4104B) in this investigation have been prepared by the method used by DAVENPORT and BAIN, and are presented on pages 908 and 909. They resemble in form the curve for S.A.E. 4140 shown in METAL PROGRESS, October 1941, page 517. It is of interest to note that, although both manganese and molybdenum shift the "S" curve of a plain carbon steel to the right (above 900° F.), the indentations of both the "beginning curve" and the "ending curve" above 900° F. are undoubtedly a specific result of the molybdenum content.

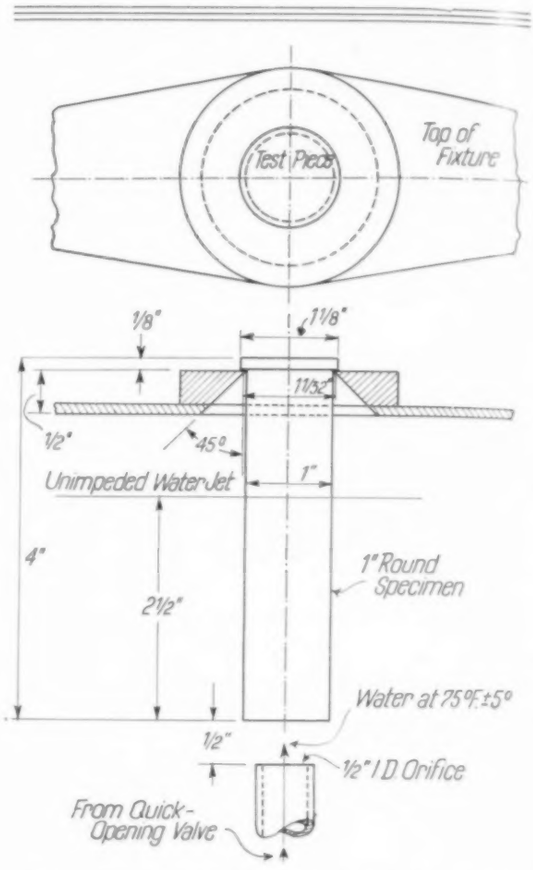
BEST HEAT TREATMENTS

A study of the form of the "S" curve above 900° F. will reveal the existence of optimum temperatures for producing specific hardnesses and microstructures. For example, both steels may be annealed to a hardness of Rockwell C-18 by austenitizing and transferring to a furnace at 1150° F., holding there for one hour in the case of the 0.17% molybdenum steel, and holding the 0.36% molybdenum steel for three hours. The rate of subsequent cooling to room temperature is essentially immaterial as far as hardness is concerned. Furthermore, if ferrite and lamellar carbide is the desired structure, the "S" curves show that it can best be obtained by allowing the austenite to transform at 1100 to 1200° F. The bay, or indentation in the curve marked "transformation ends", gives the shortest time for total reaction to *lamellar products* in the steel.

When, for purposes of machining, a non-lamellar structure is desired and means for fairly rapid cooling of the austenitized steel to 850 to 900° F. are available, an acicular structure, C-30 to 36 hard, may be obtained within 30 min. Of course, non-lamellar structures may also be obtained simply by normalizing these deep-hardening steels and tempering. It is apparent that, in any treatment for annealing these steels by direct transformation, there is little to be gained in cooling them slowly below 1050° F. and that it is more efficient to hold them in the range 1100 to 1200° F. until transformation to pearlite and ferrite is complete. Subsequent cooling can then be at any rate.

Some attention should be given to the problem of segregation. While all alloying elements tend to segregate to some extent during the solidification of steel, experience teaches us that manganese exhibits this propensity to a marked degree. If this fact is recognized, it is at once realized that manganese-molybdenum steels must be dealt with accordingly. Although it is not practical to attempt to homogenize alloy steels completely, it is certainly advisable to avoid processes and treatments that tend to exaggerate the effects of segregation. Slow cooling of these steels between Ae_3 and Ae_1 should evidently be avoided as far as possible. Such treatment concentrates carbon in the regions high in alloy content, producing relatively stable lakes of austenite that will ultimately transform to martensite unless the metal is cooled exceedingly slowly through the temperature range 1200 to 1100° F.

So far as may be determined by these laboratory tests, it can be concluded that manganese-molybdenum steels have properties which compare favorably with steels of a similar type, that is, S.A.E. 4140 and S.A.E. 4340, containing the restricted alloying elements chromium and nickel, and that no unusual difficulties may be expected in their application as alternates for steels of specific hardenability.



Fixture for Hardening Test Piece in End Quench Test on 1-In. Round Specimen as Adopted by the "Steel Standardization Group". (See pages 911 to 914)

As mentioned in "Critical Points" last month, a group of steel metallurgists headed by Fred McCleary of Chrysler Corp. has been standardizing test methods. The article below gives their agreed-upon routine for making hardenability tests, both by the method of quenching a 3-in. bar and measuring its crosswise hardness, and by the method of end quenching a 1-in. bar and measuring its lengthwise hardness. The latter is preferred by this group.

STANDARDIZATION OF HARDENABILITY TESTS

By WALTER E. JOMINY

Research Metallurgist, Chrysler Corporation, Detroit, Michigan

THERE IS a growing appreciation of the usefulness of hardenability tests as applied to steel. The test is one of the most satisfactory for checking the quality of water hardening toolsteels, and is applied successfully to oil hardening toolsteels. It is very useful in determining whether a new steel may be substituted for one whose behavior in production is known. For the past several years hardenability tests have been widely used in testing heat treating steels, and recent studies have indicated that they are useful in determining whether steels are suitable for certain types of welding.

Recognizing the importance of measuring the hardenability of steels, an active investigation was started more than five years ago by a group known as the "Steel Standardization Group" to study the most suitable means of measurement of this phenomenon. As noted in the Editor's "Critical Points" last month, this group was initiated about ten years ago by F. E. McCLEARY of Chrysler Corp. to bring about a closer cooperation between consumers and producers, especially regarding precision test methods. The group consisted of representatives of The Bethlehem Steel Co., Carnegie-Illinois Steel Corp., Chrysler Corp., Great Lakes Steel Corp., Pittsburgh Crucible Steel Co., Republic Steel Corp., and Timken Steel and Tube Co.

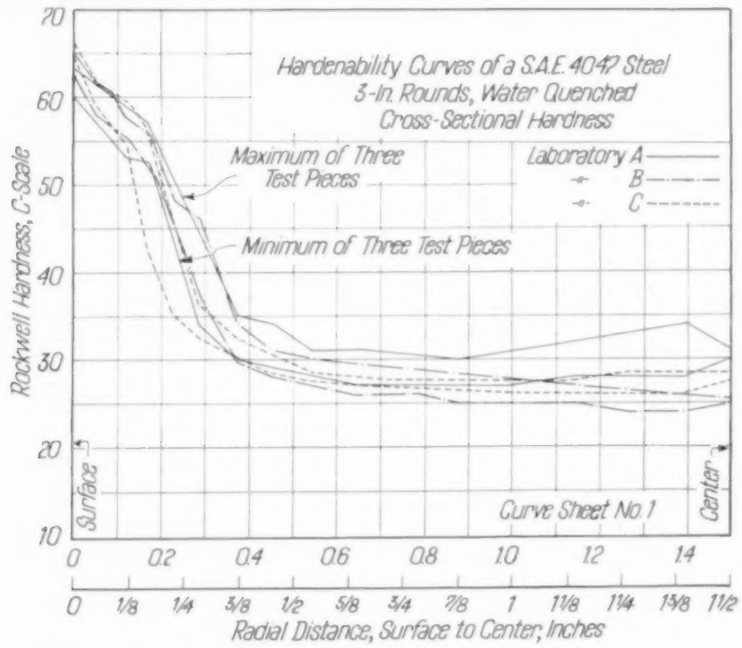
Representatives of this group made tests in their various laboratories to try out several hardenability methods and to attempt to check one another, thus determining how closely these tests could be made.

QUENCHING OF ROUND BARS

The first method studied consisted of quenching round bars of various sizes, sectioning them, and making a hardness traverse across the section. Scaling was controlled either by copper plating and heating in charcoal or by heating in a closed cylinder containing cast iron chips. All bars were normalized previous to the hardening treatment by heating 150° F. above the Ac_3 point; heating for hardening was carried out at 75° F. above the Ac_3 point. (Some variations from these temperatures to accommodate the behavior of an individual steel were occasionally used.)

Quenching was done in vertical tubes through which the quenching medium flowed at the rate of 60 gallons per min. The sizes of the vertical tubes were such that an annular space between the inside wall of the tube and the respective test pieces closely approximated 5.5 sq.in. and three guides were provided to keep the piece central in the tube. The quench-

ing medium entered the tube at the bottom through a 1⅜-in. orifice. When water was used as a quenching medium its temperature was maintained between 70 and 80°, and when oil was used the temperature was kept between 90 and 100° F. The quenching oil used was a straight-run mineral oil having a Saybolt viscosity of approximately 100 sec. at 100° F.



Curve Sheet No. 1 — Hardness Traverses of 3-In. Quenched Rounds From an S.A.E. 4047 Bar Were Made by Three Laboratories According to an Agreed-Upon Procedure. Maximum and minimum figures of tests in triplicate are plotted

After hardening, the bars were cut transversely midway between the ends under water with an abrasive cutting wheel. The cut surface of one of the two half portions was carefully ground, taking pains to avoid any frictional heat affecting the hardness. For each determination three samples were quenched and Rockwell hardness readings were made from the surface to center and to the surface again.

In the course of this work three laboratories made tests on a S.A.E. 4047 steel. Each laboratory normalized the steel at 1540° F., machined 3-in. rounds from the 3¼-in. bars received, then water quenched them from 1475° F. Curve Sheet No. 1 shows the maximum and minimum readings obtained by the three laboratories; likewise the variations in observed hardness are shown for positions of the same distance from the surface.

The composition of this steel and the others referred to in this article will be found in the accompanying table.

Steel Compositions Studied

Steel Type	Shown In Curve No.	Chemical Analysis							
		C	Mn	P	S	Si	Mo	Cr	Ni
S.A.E. 3135	3	0.34	0.50	0.018	0.024	0.16	0.02	0.48	1.26
S.A.E. 4047	1	0.49	0.76	0.019	0.027	0.26	0.24	....	....
S.A.E. 4068	4	0.65	0.78	0.017	0.026	0.28	0.25	0.03	0.03
S.A.E. 4068	5	0.65	0.79	0.018	0.018	0.25	0.23	0.15	0.20
S.A.E. 4140	2	0.42	0.83	0.022	0.014	0.32	0.23	0.89	0.13

Cooling the Ends of Cylinders

The alternate method of measuring hardenability which was tried by the Steel Standardization Group consisted of cooling the end of a 1-in. round bar with water and measuring the hardness from the water cooled end. This method was first described by A. L. Boegehold and the author in 1937. After making a number of tests and comparisons the group decided to standardize this procedure as well and chose the bar shown in the sketch on page 910. It will be observed that this bar is 1 in. longer than the one originally described by us, and that a collar on the end is used to suspend the bar. It was felt that this bar is a little more convenient to make than the original type of bar, with its drilled and tapped hole for a handle. Correlation of results shows that there is no difference in hardness of the original type of test bar and the one with the shoulder shown on page 910 for points up to 2 in. from the water cooled end, and only very little difference at 2½ in. from the water cooled end. Very few types of steels indeed would

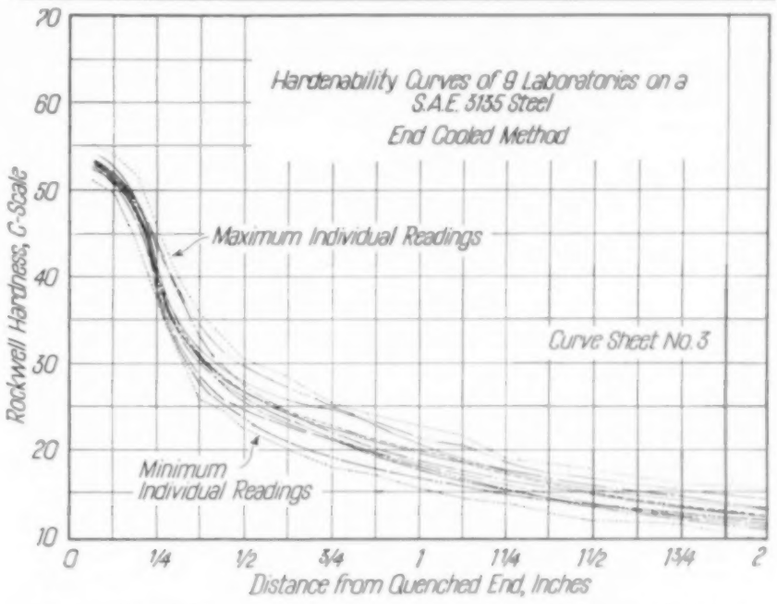
show any difference between the two bars up to 2½ in. from the hardened end, which is as far as we usually measure.

After considering and testing several alternatives it was decided to normalize the test bars by heating to 150° F. above the Ac_3 point and holding 30 min. at heat. Following this treatment the bar was finish machined and heated for hardening to 75° F. above the Ac_3 point, holding 20 min. at heat. In order to minimize scaling the bar was heated in a small closed container having a layer of cast iron chips about 1 in. deep.

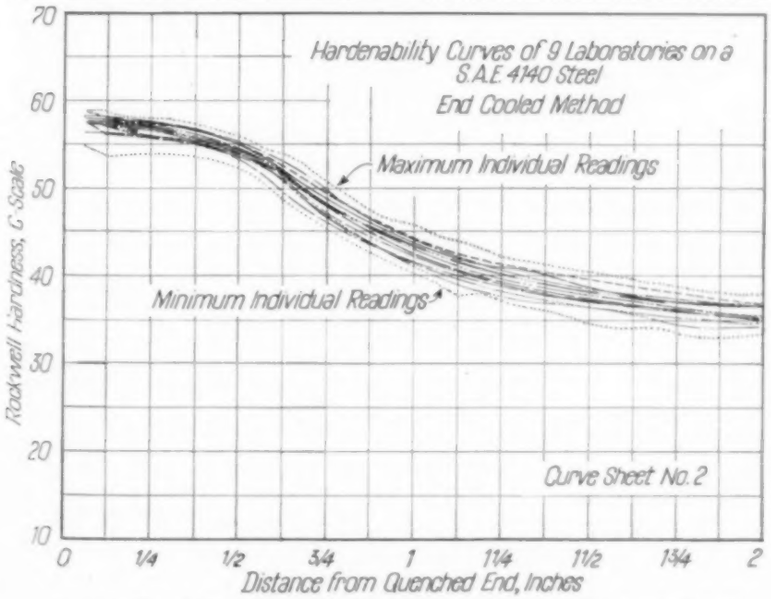
The quenching holder or fixture is mounted so that a column of water at 75° F. ± 5° is directed against the bottom face of the hot test piece. The water passes through an opening ½ in. diameter and is under sufficient pressure to rise to a height of 2½ in. above the opening before the hot steel specimen is placed in the fixture.

In performing this test the water supply is shut off with a quick-opening valve, the hot specimen placed in the fixture over the water pipe so that its bottom is ½ in. from the opening of the nozzle, and the water quickly turned on. The sample is kept on the fixture until cold, or for at least 10 min., and then quenched in water until cold.

After this treatment two flats are ground 0.015 in. deep, 180° apart, along the sides of the round bar, taking pains to grind carefully so as not to heat and so affect the hardness of the piece. Hardness readings are then made over the length of the bar at $\frac{1}{16}$-in. intervals with a Rockwell machine.



Curve Sheet No. 3 — Hardenability of One S.A.E. 3135 Heat by End Cooled Method as Determined by Nine Laboratories

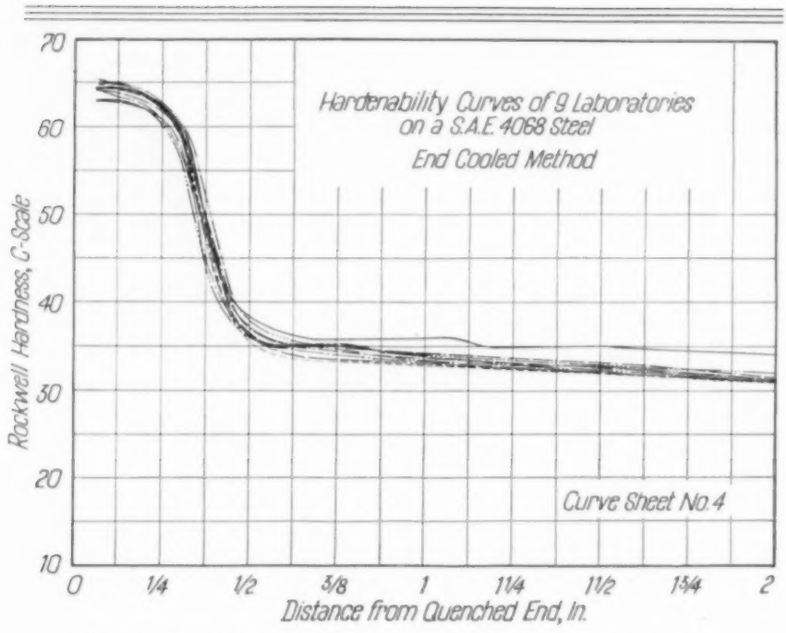


Curve Sheet No. 2 — Hardenability of One Heat of S.A.E. 4140 Steel by End Cooled Method. Average curves as determined by each of nine laboratories are plotted. Also maximum and minimum readings reported for each location

Specific Tests

Applying this procedure, a very considerable number of steels have been tested by the nine laboratories represented in the Steel Standardization Group; results of only a few tests achieved near the end of the program can be presented here. The tests described in this article however are representative.

Testing was done by having



Curve Sheet No. 4 — Hardenability of One Heat of S.A.E. 4068 Steel by End Cooled Method. Average determinations of each of nine laboratories are plotted

one laboratory furnish bars from the same billet from any one heat of steel to the other eight laboratories. Each of the laboratories reported its results in detail and in average at the next group meeting where they were compared with the results from the other eight laboratories. Four of the steels so tested are listed in Curve Sheets No. 2 to 5 inclusive.

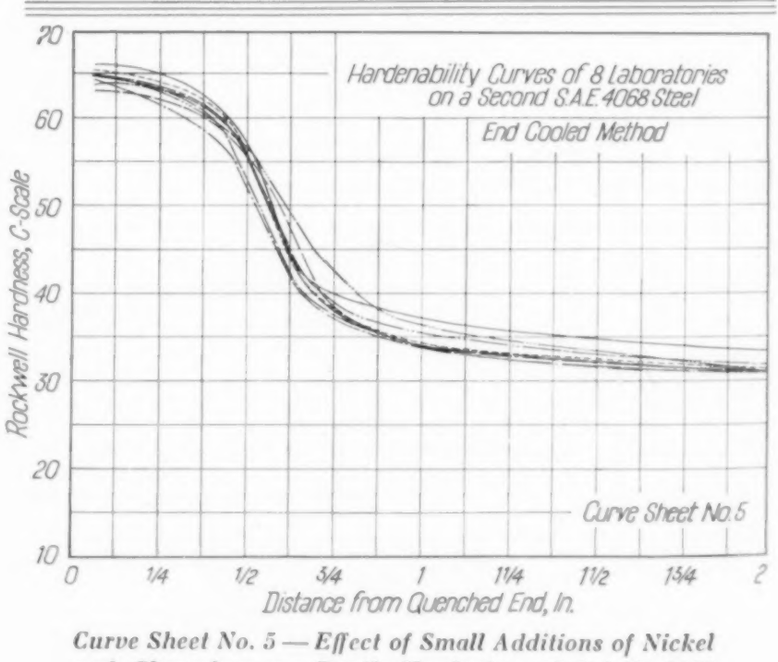
Curve Sheet No. 2 presents the data on steel S.A.E. 4140 which was normalized at 1600° F. and hardened from 1510° F. In addition to the average results from each laboratory, the curve also shows the highest and lowest hardness obtained at any given point. These are shown by the fine dotted lines. Curve Sheet No. 3 shows the results on a S.A.E. 3135 steel. This steel was normalized at 1650° F. and hardened from 1550° F. Curve Sheet No. 4 shows the results on a S.A.E. 4068 steel, normalized at 1565° F. and hardened from 1490° F.

Curve Sheet No. 5 shows the data obtained by eight of the cooperating laboratories on another heat of S.A.E. 4068 steel which contained more nickel and chromium, and consequently was deeper hardening. This steel was normalized at 1560° F. and hardened from 1485° F.

Both Methods Suitable — This article is submitted as a guide to those who are interested in adopting hardenability tests. Such testing will probably become more common in the future. It is a fact that much steel has already been supplied to hardenability requirements as determined by several hardenability methods.

The Steel Standardization Group has standardized the two methods described in this article. Particular attention is called to the fact that the details of the suggested procedures must be carefully followed to obtain reliable and comparable results.

The laboratories of the group have been using the end cooled method for production control with very satisfactory results. For most work and for general use they have preferred the end cooled method on account of its greater adaptability.



Curve Sheet No. 5 — Effect of Small Additions of Nickel and Chromium on Depth Hardening of S.A.E. 4068 Is Shown by Comparing Curve Sheet No. 5 With No. 4

Despite current increases in openhearth steel furnace capacity, actual ingot production in 1942 will be from two to six million tons less than in 1941 unless the present alarming shrinkage in current supplies of "purchased scrap" can be corrected. Three things are necessary: Drain the country of scrap now; build more blast furnaces rapidly to make iron when this supply dries up; schedule present operations of the industry by expert steel men.

WHAT CAN AND WHAT CANNOT BE DONE IN STEEL EXPANSION

AT A MEETING of the Association of Iron and Steel Engineers in Cleveland, November 21, ARTHUR G. MCKEE, the well-known specialist in iron and steel plant design and construction, said that figures he had assembled at the behest of JESSE H. JONES, administrator of the Federal Loan Agency, indicated the production of a *lower* tonnage of American steel in 1942 than we are making this year. This despite a 4,000,000-ton increase in openhearth *capacity* installed during 1941, and a general and vocal dissatisfaction with present steel deliveries by defense officials, especially Rear Admiral EMORY S. LAND, chairman of the U. S. Maritime Commission, in charge of our shipbuilding program. The figures were made public, and are here discussed at length, in the hope that the viewpoint of capable engineers may receive adequate attention, and that some corrective action would be taken by top Washington officials before the situation becomes more critical.

IS PLATE CAPACITY ADEQUATE?

Mr. MCKEE was asked by Mr. JONES in October to advise him on the adequacy of the plate producing capacity. There were no figures available in OPM as to the *needs*, but somewhat later A. D. WHITESIDE, chief of the Iron and Steel Branch, telephoned that the amount for 1942 would, he thought, be in the neighborhood of 8,500,000 tons. Meanwhile he had compiled the following figures (net tons) for mill capacity:

		NET TONS CAPACITY
Sheared plate		
134 to 200 in.	1,275,000	
90 to 128 in.	2,945,000	
under 90 in.	955,000	5,175,000
Universal plate		
wide plate	790,000	
mills under 60 in.	1,710,000	2,500,000*
Strip mills		
48 to 92 in.	3,580,000	
less 35% for shear scrap	1,255,000	2,325,000
Total present capacity, if properly scheduled		10,000,000

*Actual production of universal plate is now on the order of 1,000,000 tons per year, because some mills are not in operation.

This total comes out in suspiciously round numbers, but indicates that there is surplus rolling *capacity* for the round figure of 8,500,000 tons of plates earmarked in 1942 by Mr. WHITESIDE for defense, "lend-lease", and industrial requirements. Beyond the ten million tons above listed, three million additional could be got from the wide strip mills by the installation of more plate handling equipment on the finishing side. No narrow strip mills are included above; we can produce 5,500,000 tons of *strip* in mills from 24 to 48 in. wide, and 3,350,000 tons in narrower mills. Most of these could produce a considerable tonnage of *plates* if provided with cooling beds, levelers and shears, which could be installed in a short time and at a low

cost as compared to completely new plate mills. An idea of what the size of these figures means may be had from the statement that 1½ million tons of plate would launch one cargo boat every day for an entire year.

Since the question of plate *supply* is so important, it is equally important to discover whether shortages complained of by Admiral LAND are due to faulty buying and scheduling rather than insufficient capacity to produce. For this reason another estimate of American capacity was furnished to the EDITOR by an engineer having access to the records of one of the principal American firms manufacturing heavy rolling mill machinery. His estimate follows:

Sheared plate	5,441,000 tons
Universal plate	1,521,000 tons
Strip mill plate	3,000,000 tons
Total	9,962,000 tons

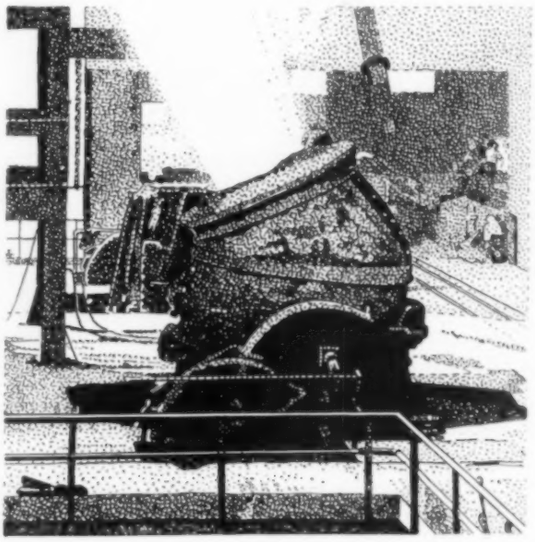
This engineer also observed that the capacity of 48 to 92-in. strip mills quoted by Mr. MCKEE was very conservative, and that his allowance of 35% for shear scrap is quite high, in view of actual figure of 15 to 18% scrap on large semi-continuous plate mills. Some of the universal and sheared plate mills have been idle for many years, and would require considerable rehabilitation; likewise the adjacent steel making furnaces are supplying other busy mills, and the necessary ingots or slabs would have to be shipped in, but all capacity in this second table could be quickly put into shape. He says: "It is absolutely surprising the tonnage which is available from the strip mills providing the necessary additional equipment is installed, and some plants require very little."

These two estimates are close enough in agreement to show that our present plate mill capacity is adequate for the needs of 1942 as predicted by Mr. WHITESIDE.

HOW CAN CAPACITY BE OBTAINED?

EUGENE G. GRACE, president of the Bethlehem Steel Co., at the meeting of the iron and steel industry with the Office of Production Management in Washington on Armistice Day, once again emphasized the necessity for proper scheduling of orders if anywhere near the maximum is to be got from the steel industry. That is especially true of the plate mills. He described for the benefit of the Washington officials the function of the order department of a large steel organization, and how necessary it was to know *what* was needed, *where* it was needed and *when* it was needed. Then only could the required material be produced and shipped properly. Lacking the equivalent of such an order department in OPM (which is now directing the industry by priorities, and in some departments by allocations) it is only to be expected that large mills will frequently run below capacity when they are making plates that could better be rolled on a smaller mill somewhere else.

It is, of course, common knowledge that the total finishing capacity, that is, of the rolling mills, far exceeds the country's total ingot capacity, and the steel industry has long been



aware that the total ingot capacity is considerably greater than the supply of pig iron plus available scrap. So any demonstration of adequacy of plate mill capacity should also imply that we have enough openhearth steel capacity for these and other demands, but that in turn we should examine carefully into the supply of raw material to make the steel, which involves scrap supply, blast furnaces for pig iron, coke, iron ore, its transportation, and flux. Openhearth, bessemer, and electric furnaces can be built much faster than blast furnaces, and unfortunately as a result of raw material shortage our present openhearth production has already slipped off alarmingly. Mr. MCKEE's figures show that there will not be enough scrap iron and pig iron to continue even at the present rate, let alone enough for any further expansion in openhearth capacity.

Pig Iron Shortage Visualized Early in 1941

That the pig iron capacity of this country is not in line with ingot steel capacity was noted as long ago as Feb. 22, 1941 in Gano Dunn's first "Report to the President on the Adequacy of the Steel Industry for National Defense". Mr. Dunn rather under-estimated the pig iron requirements of the foundry industry, and like everyone else he had to guess about the scrap situation. In that report he estimated, as of Dec. 31, 1940:

		Net Tons
Ingot capacity, normal rating		84,152,292
Maximum reliable capacity; steel ingots at 102.5%, plus "outside" steel castings		87,576,099
Total of all charge material required		96,333,708
Pig iron in above		49,809,344
Total blast furnace capacity (normal rating)	57,609,590	
Less for foundry iron and ferros	9,200,000	
Pig iron available		48,409,590
Deficit in pig iron anticipated		1,399,754
Deficit in coke capacity		4,532,411

He said the apparent deficit in pig iron would largely disappear because of more-than-nominal production from the large new blast furnaces. However, 1,399,754 tons of pig iron (the anticipated deficit) could be made by four 1000-ton per day furnaces, and it would be comforting to have them running now, when purchased scrap is getting scarcer and scarcer. The coke deficit was more serious; it represented 10.3% of the capacity on Dec. 31, 1940. At that time some 614 by-product ovens were under construction or negotiation, representing an annual capacity of 3,165,600 net tons, which would just about keep the then existing blast furnaces operating at capacity. (It takes 0.88 ton of coke to make one ton of pig iron.)

Three months later Mr. Dunn made his second report to the President (May 22, 1941). The intervening time was one when "business as usual" — even more so — was the slogan of Washington, and there was great political pressure on the steel industry for a large expansion. Mr. Dunn found that no less than 28 steel companies were adding to ingot capacity, bringing the maximum reliable capacity for ingots and outside castings to 91,338,669 tons as of Dec. 31, 1941. In addition to this, a 1,115,200-ton expansion on the Pacific Coast had been recommended by W. A. Hauck, consultant of the Iron and Steel Branch of the OPM, which would be ready sometime after the turn of the year.

It was also possible for him to compute more accurately the blast furnace capacity to be expected at the beginning of 1942. Seven steel companies had blown in, or were building or modernizing furnaces; the anticipated 1942 production would therefore be 2,772,620 tons greater than the anticipated 1941 production. Pig iron in 1942 would then be 60,382,210 tons, from which must be deducted an apportionment for foundry iron and ferros. Blast furnace capacity appeared to be expanding somewhat faster than ingot capacity, so Mr. Dunn dismissed the menace of raw material shortage, other than what might arise from an unknown increase in foundry demand over and above the ability of the merchant furnaces to supply. (Merchant blast furnaces are not included in Mr. Dunn's figures.) Unfortunately for this prediction about sufficiency of raw materials, there has not been enough scrap to make up his 50:50 ratio assumed for the openhearth charge.

By mid-1941 the coke supply had also become less critical because of the rehabilitation of old beehive ovens, producing at the rate of 2,450,000 tons annually. On the whole, some 6,896,400 tons of coke will be produced in 1942 over the estimated 39,299,812 tons for 1941, an amount sufficient to take care of the expanded blast furnace capacity for the coming year.

Mr. Dunn's second report was therefore a reassuring one, showing that the industry — largely on its own initiative and with its own money — was expanding not only its total production but also those auxiliaries necessary for the final result.

Larger Steel Output Planned

At about the same time, Stacy May, chief of the OPM's Bureau of Research and Statistics, had promulgated estimates of civilian consumption based on anticipated national income rather than on our ability to produce and fabricate. These estimates when added to defense requirements totaled to 101,900,000 tons of steel ingots in 1941 and 120,400,000 tons of steel ingots in 1942. The latter figure appeared almost fantastic to Mr. Dunn, who believed there would not be enough workmen in the country to make, fabricate, transport and put into use any such

Estimates of Steel Production (Arthur G. McKee)

	1942	1943
Pig Iron, Purchased Scrap and Steel		
Expected pig iron production of 1941	55,800,000	55,800,000
Expected increase in pig iron capacity	2,875,000	7,567,000
Total expected pig iron production	58,675,000	63,367,000
Deficiency in purchased scrap	5,000,000	5,000,000
Pig iron to compensate scrap deficiency	5,556,000	5,556,000
Scrap from additional ingots (over 1942)		917,000
Net shortage (or surplus) of primary metals	− 2,681,000	+ 2,928,000
Additional synthetic scrap required	4,249,000	5,564,160 *(a)*
Estimated steel production of previous year	83,000,000	80,640,000
Shortage (or gain) due to primary metals	− 2,360,000	+ 2,560,000
Estimated steel production	80,640,000	83,200,000
Lake Superior Iron Ore		
Lake ore used in 1941	83,100,000	83,100,000
Additional lake ore required	4,165,000	10,934,300
Total lake ore required	87,265,000	94,034,300
Lake ore carrying capacities (existing ships)	90,700,000	
Deduct Canadian requirements	2,000,000	
Old capacity available	88,700,000	88,700,000
Delivered by new boats in service	1,680,000	8,675,000
Total ore carrying capacities	90,380,000	97,375,000
Surplus ore carrying capacity	3,115,000	3,340,700
Coking Coal and Furnace Coke		
Additional furnace coke required over 1941	2,530,000	6,660,000
Additional coking coal required over 1941	3,800,000	10,100,000
Additional coke ovens	400	1,070

(a) Requires 11 bessemer converters

amount of steel, and that it would seriously interfere with our rearmament efforts as then planned even to try to expand the capacity of the industry by any such figure.

Nevertheless, the disparity between what Mr. MAY said would be needed and what Mr. DUNN said could be had with existing equipment was so great that President ROOSEVELT asked Mr. KNUDSEN for a report on the possibility of increasing the ingot capacity of the steel industry by 10 million tons, including all auxiliary facilities. Mr. DUNN thereupon resigned and his advisory office was assumed by W. A. HAUCK, who had originally strongly recommended an expansion of the industry in the West.

Mr. HAUCK reported on Sept. 24 that 10,000,000 tons including all necessary auxiliaries could be added in less than two years, over and above the 3,028,498 tons under way at date, bringing the total ingot capacity of the country to 99,000,000 tons per year as of June 30, 1943, at a cost of 1¼ billion dollars. The OPM was instructed to proceed with this expansion on Oct. 1, 1941. At OPM's meeting with the steel industry on Nov. 11, Mr. HAUCK said that two-thirds of this expansion program has been definitely allocated to the various steel companies. No information was given as to what part of it had been financed.

It is difficult to follow Mr. HAUCK's report in its details, for a clear distinction is not made between the facilities already contracted for or under construction and those yet to be engineered and financed. For the additional 10 million tons of open-hearth steel he estimates the need of 6,508,950 tons of pig iron from 15 new blast furnaces, 9,800,000 tons of lake ore, and 25 new boats to carry it. In view of the scrap shortage, he also plans on at least 1,000,000 tons of bessemer steel capacity for "synthetic scrap". (By Nov. 11 he had increased this figure to 2,600,000 tons.) His estimates as to steel, labor, and time required for such a program are also considerably lower than Mr. DUNN's.

Later in November the Iron and Steel Branch of the OPM issued a chart showing the expected steel capacity by the end of 1943, which indicates a substantial downward revision of Mr. HAUCK's original figures.

Steel Capacity	FIGURES IN NET TONS	
Existing now	86,148,000	
Privately financed	2,808,000	
Governmental	4,032,000	92,988,000
Pig Iron Capacity		
Existing now	56,937,000	
Privately financed	3,501,000	
Governmental	6,980,000	
Deduct merchant iron	− 9,000,000	58,418,000
Iron Ore For Blast Furnaces and Openhearths		
Lake Superior ships	89,500,000	
Canadian ships	3,000,000	
Privately financed (5)	2,500,000	
Governmental (25)	10,000,000	
Total lake ore	105,000,000	
From other sources	20,400,000	125,400,000

STEEL REASONABLY TO BE EXPECTED

A. D. WHITESIDE, retiring chief of OPM's Iron and Steel Branch, was much less optimistic than Mr. HAUCK at the Armistice Day meeting. He expects the following *production:*

In 1941	84,000,000 net tons of steel
1942	82,600,000
1943	86,000,000

Note the drop in 1942 production! If these

figures are correct there would be no need until 1944 for more openhearth furnaces than we now have. At this same Washington meeting, R. C. ALLEN, assistant chief of the Iron and Steel Branch of OPM, and expert as to iron ore and pig iron production, gave the following estimates stemming from an anticipated figure of 23,000,000 tons of purchased scrap (a figure admittedly hazardous to estimate):

	1942	1943
Ingot capacity (normal rating)	87,000,000	93,000,000
Expected steel output	83,000,000	86,000,000
Purchased scrap available	23,000,000	23,000,000
Pig iron produced	58,100,000	60,200,000
Pig iron deficit*	6,400,000	9,800,000
New blast furnaces required		32
Iron ore for available furnaces	84,860,000	90,000,000
New lake ore boats required		16

*If this were available, steel furnaces could run at capacity.

The ore boats are now on order by the Maritime Commission and are scheduled for delivery before June 15, 1943.

A report was recently made to OPM, by an executive of one of the important factors in the iron ore trade, on the ore carrier capacity and its relation to pig iron and steel. In the table on page 918 Mr. MCKEE has estimated maximum expected steel production in 1942 and 1943 on certain data from this report, and an assumed deficiency of 5,000,000 tons per year of purchased scrap. (This is in line with Mr. ALLEN's estimate for 1942, although M. D. HARBAUGH, vice-president of the Lake Superior Iron Ore Association, estimates it 20% higher.) These figures show what a surprising influence scrap shortage has upon steel production. WM. C. BUELL, authority on openhearth furnaces, estimates that at *present* rates of pig iron and scrap consumption we will make 6,000,000 tons of steel *less* in 1942 than in 1941.

On the same bases, Mr. MCKEE derives some figures to show what will be necessary to get 10,000,000 more tons of actual steel beyond the 83,000,000 tons of ingots anticipated for 1941. These are given in the last table, and indicate that 33 blast furnaces will be required to make the necessary 13,216,000 tons of additional pig iron, 1850 new byproduct coke ovens would have to be constructed, 49 more Maritime Commission boats are needed if all the ore is to come down the Lakes, and 14 large bessemer converters for synthetic scrap. This is twice as many blast furnaces and ore boats as Mr. HAUCK estimated in his original report on a 10-million ton increase in steel, and three times as much synthetic scrap. The ore boat building program which now irks the Maritime Commission would also have to be tripled. A further estimate of the difficulties attending such a program is that unless some drastic expansion in facilities is possible, our industry can produce about eight blast furnaces per year. Deliveries on blowing engines are now quoted at 24 months. Likewise it takes from 9 to 12 months to construct a furnace, when ample raw materials are available, the time depending on the amount of preliminary engineering and financial work that has been done before the contract is let.

GET OUT THE SCRAP!

In conclusion, as at the outset, it is to be hoped that these figures, acquired by as competent engineers as the American steel industry possesses, may be impressed on the planning officials in Washington. It is obvious that raw materials constitute the bottleneck in steel production. It is of paramount importance that dormant scrap be collected by the millions of tons. Meantime blast furnaces must be built with all possible speed, and ore and coke supplies arranged for. *Then* we can usefully turn some attention toward more openhearth furnaces and rolling capacity.

Facilities Needed to Increase Steel Output by 10,000,000 Tons*

Steel production in 1941	83,000,000
Additional future steel production	10,000,000
Total future steel production	93,000,000
Pig iron used in 1941	55,800,000
Future deficiency in amount of scrap	5,000,000
Pig iron required to compensate scrap deficiency	5,556,000
Pig iron required in making 10,000,000 tons of steel	7,660,000
Total additional pig iron required	13,216,000
Total future pig iron production	69,016,000
Plant scrap from 10,000,000 tons of ingots	2,500,000
Factory scrap from 10,000,000 tons of ingots	1,000,000
Additional blast furnaces required	33
Additional furnace coke required	11,630,000
Total additional coking coal required	17,500,000
Additional coke ovens required	1,850
Additional lake iron ore required	19,097,200
Additional Maritime Commission boats	49
Additional iron ore required from other sources	3,370,000
Additional "synthetic scrap" required	8,447,400
Additional bessemer vessels for scrap	14

*Estimate in net tons of the amounts of pig iron, iron ore, furnace coke, coking coal and scrap and of certain facilities, required in producing an additional 10,000,000 tons of steel, by Arthur G. McKee. Based on certain data from the report referred to in the middle of the left hand column on this page.

PERSONALS

Lars H. Nordenson is now working for the Union Oil Co. of Calif. in the research department at Wilmington, Calif.

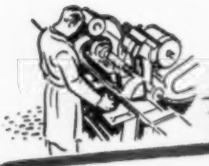
Ernest E. Qvarnstrom is now employed in the heat treating department of Bendix Aviation Corp., Philadelphia.

Robert Fricker has been moved from Montreal to the western branch of the Dominion Bridge Co. in Vancouver, B. C.

G. Lewis Perkins is now employed in the metallurgical department of the American Steel & Wire Co., Cleveland.

Wesley M. McGhee, formerly of Continental Motors Corp., Detroit, is now chemist for the Barrett Co. of Chicago.

In Grinding...



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Walter M. Mitchell has been made chief metallurgist for York Safe and Lock Co. in the Special Ordnance Plant, York, Pa.

Oliver Smalley, president, Meehanite Metal Corp., Pittsburgh, has been elected president of the Meehanite Research Institute of America. **H. B. Hanley**, American Laundry Machinery Co., Rochester, N. Y. is vice-president, and **Frank M. Robbins**, president, Ross-Meehan Foundries, Chattanooga, Tenn., has been elected secretary-treasurer. At the annual meeting of the Institute **A. C. Denison**, president of the Fulton Foundry & Machine Co., Cleveland, was presented with a gold watch for his meritorious services.

D. S. Jacobus, advisory engineer, Babcock & Wilcox Co., retiring chairman of the Boiler Code Committee of the American Society of Mechanical Engineers; and his successor as chairman, **Edwards R. Fish**, chief engineer, Boiler Division, Hartford Steam Boiler Inspection and Insurance Co., were honored by the A.S.M.E. with a dinner at the Engineers Club.

Alexander Gobus, metallographer, Lucius Pitkin, Inc. has been elected to the vice-chairmanship of the New York Chapter, to succeed the late **Hugh Menihan**. Two vacancies in the executive committee have been filled by **Harold Malm** of the Callite Tungsten Corp. and **George W. Strahan** of the International Nickel Co.

John H. Fischel, formerly with the Hume Steel Co. of Chicago, is now with the Goss Printing Press Co.

James L. Rushing, formerly stationed at Duncan Field, San Antonio, Texas, is now heat treater (aviation), U. S. Naval Air Station, Corpus Christi, Texas.

Andrew J. Repko is now employed at Wright Field, Dayton, Ohio, in the experimental unit.

That's the situation your telephone company faces every Christmas. That's why there may be delays on some Long Distance Christmas calls.

• Last Christmas Eve and Day the wires were jammed. The switchboards were manned by regular and extra operators working all through the holiday. Long Distance telephone calls were three, five and at some places *eight* times normal.

We're glad so many folks want to exchange friendly greetings across the miles at Christmas — but sorry that, because of it, we can't supply service as good as usual.

We expect the biggest rush of calls we've ever had this coming Christmas. We'll do our best to prepare for it. But some calls will be slow. Some may not be completed. For these, we ask your patience and understanding. . . . *Thank you, and Merry Christmas!*

BELL TELEPHONE SYSTEM

PERSONALS

Ensign John J. Daly is now stationed at the United States Naval Air Station at Alameda, Calif. in the assembly and repair department.

Chester Kondy is now connected with the National Malleable & Steel Castings Co., Cicero, Ill. in the melting department.

Lt. George R. Weinbrenner has been transferred from Aberdeen Proving Grounds, Md. to Selfridge Field, Mich. where he is assigned to the 695th Ordnance Co. attached to the Air Force Combat Command.

C. C. Faroni, metallurgist, formerly of Crucible Steel Co. of America in Harrison, N. J., is now in charge of melting operations at the Roxborough Steel Co., Philadelphia.

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I. N. Zavarine, formerly instructor in metallurgy at Massachusetts Institute of Technology, is now in the Bureau of Aeronautics, Navy Department, Washington, D. C.

Lt. Stewart W. Worden has been assigned a permanent station at the Louisiana Ordnance Plant, Shreveport, La.

Stephen C. Smith is now metallurgist with the Dow Chemical Co., Midland, Mich.

John M. Sherry, formerly with the W. B. Coleman & Co. Consulting Laboratories of Philadelphia, is now employed at the Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

William A. Roth, formerly machine and tool superintendent, Republic Aviation Corp., Farmingdale, Long Island, N. Y., is now factory superintendent, McDonnell Aircraft Corp., St. Louis, Mo.

J. W. Parks has been assigned to represent the Standard Oil Co. of California on materials work in the middle west and east.

Richard C. Smith, formerly in the metallurgical department, National Tube Co., Lorain, Ohio, is now in New York for a two-months course in naval indoctrination.

Joseph F. Lange, formerly with Westinghouse Electric & Mfg. Co., is now a practice apprentice in the industrial engineering division, Carnegie-Illinois Steel Corp.

F. O. Traenkner, Pennsylvania State College, '41, is now metallurgist in the tube department of the Lafayette, Ind. works of the Aluminum Co. of America.

R. E. Wiley, formerly metallurgical engineer, National Tube Co., Lorain, Ohio, is now associate engineer (materials), Navy Department, Bureau of Ships, Washington, D. C.

Operating savings obtained from high steam temperatures and pressures would justify using expensive steels to avoid steam line trouble. Fortunately, an inexpensive Carbon-Molybdenum (0.50% Mo) steel does the job.

Its creep strength up to 1000° F, plus its easy weldability, make for light, leak-proof lines. The use of thinner sections sometimes reduces the already small cost differential over unalloyed steels.

Write for technical book, "Molybdenum in Steel".

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MOLY

PERSONALS

Promoted at the U. S. Navy Yard, New York: **N. A. Kahn** from metallurgist to senior metallurgist; **E. A. Imbembo**, from assistant materials engineer to associate metallurgist; **J. Bland**, from assistant metallurgist to associate metallurgist; **S. Goldspiel**, from scientific aide to assistant materials engineer; **B. N. Ames**, from scientific aide to junior metallurgist.

John H. Van Reyendam is now employed at the Aviation Engine Plant of General Motors Corp., as a protective coating engineer.

Andrew B. Filicko has been made senior foreman in the heat treating department of the United States Cartridge Co., St. Louis.

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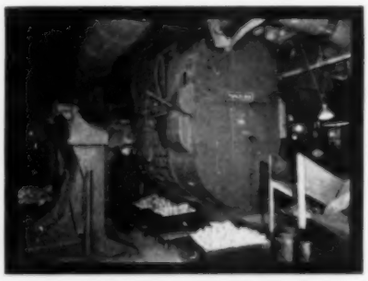

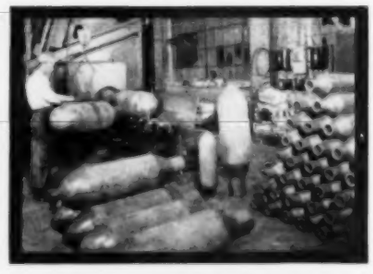

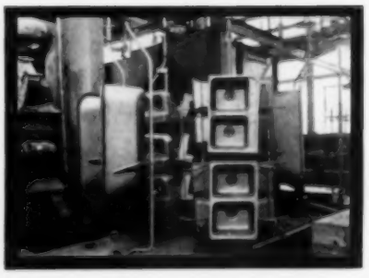

"ROTOBLASTING" is the easy way to say airless blast cleaning. Many men in steel mills, forge shops, heat treating departments, etc., use "ROTOBLASTING" as an expression meaning a better way to produce bright smooth surfaces free from scale on work requiring machining, grinding, and other finishing operations.

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"ROTOBLASTING" has proven a surprising money saver in many ways. It has cut cleaning time and lowered cleaning costs as much as 50% in many applications. It is handling work three times as fast as former methods. It reduces labor requirements, lowers power costs, and increases production schedules as much as 200%.

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Pangborn engineers are conveniently located to work with you or your representatives in making proposals to suit any of your blast cleaning and dust control requirements. These men are all specialists in these fields — and their many years of successful experience qualifies them to serve you to your most profitable interest. No obligation for consultation or suggestions, of course.

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Promoted by Thompson Products Co.: **Harry D. Bubb**, from chief engineer to director of engineering for the Cleveland plant and also for Thompson Aircraft Products Co., a subsidiary.

P. A. Archibald has resigned his position with the Denver & Rio Grande Western Railroad to become associated with the Standard Steel Works Division of Baldwin Locomotive Works, Burnham, Pa., as research metallurgist.

Robert W. Alcock is now employed by Lockheed Aircraft Corp., Burbank, Calif., as production trainee.

Thomas J. Scott has resigned as chemist and metallurgist with the Empire Sheet and Tin Plate Co. of Mansfield, Ohio, to accept a position with the Ordnance Department in Cleveland.

Martin F. Richter, formerly with the Perfection Tool & Metal Heat Treating Co. of Chicago, is now connected with the California Steel Treating, Inc. of Los Angeles, in charge of sales and consulting.

Frank B. Hays, formerly employed by Worthington Pump and Machinery Corp., is now instructor in the division of aircraft and automotive engines, Department of Mechanical Engineering, Massachusetts Institute of Technology.

Transferred by Nicholson File Co. from a New England territory to Chicago and midwest territory: **G. Kenneth Shaffer**, sales engineer.

C. S. Chisolm, formerly openhearth observer in the metallurgical department, Tennessee Coal, Iron & Railroad Co., has been called to duty as 1st lieutenant in the Field Artillery at Fort Benning, Ga.

O. V. Greene, assistant metallurgist of the Carpenter Steel Co., Reading, Pa., has been named manager of toolsteel sales.

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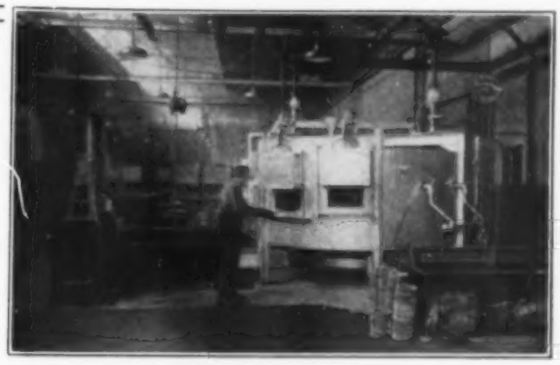

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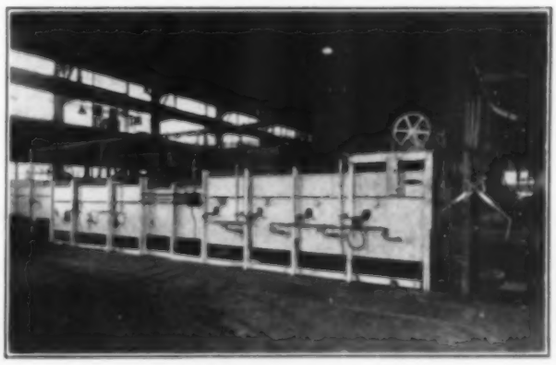

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NOTES ABOUT CONTRIBUTORS

Fred E. McCleary had been with Dodge Bros. long prior to its absorption by Chrysler Corp., and is one of the pioneering automotive metallurgists in the Detroit region. At present he is metallurgical engineer for Chrysler Corp. and Dodge Bros. Division. Mac is an active member of the Detroit Chapter, and is also chairman of the Steel Standardization Group, whose activities were described in last month's "Critical Points".

One result of the work of this Steel Standardization Group is the standardization of the hardenability test as described by **Walter Jominy** on page 911 of this issue. Since Jominy's last appearance as an author in METAL PROGRESS he has joined Chrysler Corp. as metallurgist in the engineering department. Prior to that he held a similar position in the General Motors Research Laboratories; other details of his career are outlined on the Authors' Page, November 1940 METAL PROGRESS.

The three authors of the article on the manganese-molybdenum steels (page 906) are all under 40, all have a Master's degree, and all have spent most of their careers in Climax Molybdenum Co.'s research laboratory. **James R. Blanchard** received his B.S. and M.S. from Ohio State University and was the Battelle Memorial Institute fellow there in 1933-34. He was employed by the Hocking Glass Co., Lancaster, Ohio, from 1934 to 1937, and has been metallurgist at Climax since then. **Robert M. Parke** got his degrees in 1926 and 1933 from University of Michigan, and has been on the Climax research staff since the latter date. **Alvin J. Herzig** also received his B.S. at Michigan in 1926. For the next two years he worked in the laboratory of National Supply Co., Toledo, and then received a staff appointment to the department of engineering research at Michigan in 1928. After receiving his Master's degree in 1931, he came to Climax Molybdenum Co. as chief metallurgist.

The originator of the ingenious interconversion chart from atomic to weight per cent which forms this month's data sheet, **Ray P. Dunn**, is a product of Purdue University (B.S.Ch.E. 1937). For two years he acted as teaching assistant in metallurgy at the University of Minnesota, from which institute he received an M.S. degree in 1940. Since 1939 he has been employed as research metallurgist for the Electro Manganese Corp. of Minneapolis.

Long experience in the foundry field lends weight to **Harold S. Austin's** timely views on alloy supply on page 886. As foundry metallurgist for Buick, he has written many an authoritative article on cast steels and irons. His 30-year career in this field was outlined in METAL PROGRESS a year ago, when he presented an article on "Production of Automotive Castings". Currently he is chairman of the very active Saginaw Valley Group of the Detroit Chapter.

FRED E. MCCLEARY

RAY P. DUNN

JAMES R. BLANCHARD

ALVIN J. HERZIG

ROBERT M. PARKE

LITERATURE

Columbium

"Advantages of Columbium in Wrought 4 to 6 Per Cent Chromium Steel" is the title of a booklet made available through the Electro Metallurgical Co. which gives detailed test data to prove its advantages. Bulletin Cc-16.

Fabricating Stainless

A helpful 28-page booklet that gives valuable facts on welding, drawing, machining, spinning, forging, riveting and other fabrication methods for stainless steels is available through Allegheny Ludlum Steel Corp. Bulletin Ke-92.

Tool Steel Selector

A very handy sliding tool steel selector which lists the characteristics of 27 tool steels and shows their application is available through the Ziv Steel & Wire Co. Bulletin Ge-313.

Die Steel

A "New Process" Cold Header Die Steel developed especially to meet severe service conditions encountered when cold-heading bolts, nuts, screws, etc. is described in an 8-page folder by the Jessop Steel Co. Bulletin Ne-173.

Graphitic Steel

A newly revised and enlarged Fifth printing of the popular Graphitic Steel Booklet has just been issued by the Steel & Tube Division, Timken Roller Bearing Co. Bulletin Ne-71.

Meehanite Castings

A new 12-page bulletin "Meehanite Castings in Defense Work" has just been published by the Meehanite Research Institute of America, Inc. Bulletin Ne-165.

Molybdenum Reference

A very impressive spiral-bound 128-page book explaining the uses and properties of Molybdenum steels and irons is being made available by the Molybdenum Corp. of America. Bulletin Ge-312.

N-A-X

A twenty-page, fully illustrated booklet on N-A-X high tensile low alloy steel has been published by Great Lakes Steel Corporation. This steel has been thoroughly proved in applications where ordinary high tensile steels have failed. Bulletin Kd-229.

Free Machining

Reserve your copy of new twenty-page story of Speed Case and Speed Treat. This booklet covers physical properties, compares this W. J. Holliday & Co. steel with SAE 1020 and others. Explains how manganese and sulphur content plus patent manufacturing processes produce free machining combined with comparatively high physical values. Also contains machinability carburizing tables and pictures applications. Bulletin Kd-293.

Hard Facing Alloys

For maximum resistance to wear and corrosion, the Wall-Colmonoy Corp. offers a fact-packed folder which is extremely helpful to anyone having this problem. Bulletin Kd-85.

Free Machining Steels

Speed Case and Speed Treat, two steels with increased machining properties, are described in literature available through Monarch Steel Co. Bulletin Cd-255.

18-8 Types

Properties, fabrication, corrosion-resistance and applications of Republic Steel Company's ENDURO 18-8 are covered in a new 24-page booklet. Bulletin Be-8.

Alloy Steels

Special Quality tool and electric furnace alloy steels are featured in a new folder by Copperweld Steel Co. Bulletin Ge-311.

Tool Steel

If you produce dies, punches, or similar tools (and are using liquid-quenched steel) investigate the Air-Hardening Tool Steel produced by the Bethlehem Steel Co. Bulletin Ce-76.

Stressproof

A new Cold Finished Bar is introduced in a colorful booklet released by the LaSalle Steel Company. Well illustrated, the booklet also contains tables showing substantial savings made by the use of this new steel. Bulletin Lb-52.

Die Steels

For applications where toughness and the ability to withstand wear is essential, the G.S.N. Die Steels described in Latrobe Electric Steel Co.'s booklet fill the bill. Bulletin Ld-208.

Steel Data

Ten colorful leaflets, each describing a popular grade of tool or high speed steel and giving useful data, application information, etc., have been issued by Vanadium-Alloys Steel Co. Write for Bulletin Kd-294.

Nitralloy

Nitralloy, the alloy steel that produces the hardest steel surface known, is described in the Nitralloy Data Book. Bulletin Ke-116.

Heat Resistant Metals

Refinery Alloys

Special alloys for refineries, corrosion, temperature, and abrasion resisting are covered in a colorful folder produced by the Duraloy Co. Bulletin Kd-233.

X-Ray Inspected Castings

All types of heat and corrosion resistant castings made with extensive use of "X-Ray Inspection" and modern foundry methods are shown and described in a 16-page two-color booklet made available by the Electro-Alloys Co. Bulletin Ld-32.

Melting • Casting

Foundry Sand

A pamphlet issued on TAM Foundry Zircon Sand and TAM Zircon Flour contains detailed information on these products of the Titanium Alloy Mfg. Co. Bulletin Hc-90.

Aluminum Castings

An aluminum casting alloy is announced by the National Bronze and Aluminum Foundry Co. of Cleveland. Known as the T-1 aluminum alloy, it has a tensile strength up to 33,000 psi. without heat treatment. A folder gives complete data, composition and detailed information. Bulletin De-307.

Ingot Production

"The Ingot Phase of Steel Production" is the title of a book defining the principles of quality ingot production followed by many well-known steel manufacturers. Gathmann Engineering Co. Bulletin Ka-13.

Pit Handbook

A virtual handbook on soaking pit procedure best describes the booklet published by Amsler-Morton Co. Included are comprehensive case histories of pits now in successful operation. Bulletin Kd-286.

Finishing • Plating • Cleaning

New Cleaning Process

A new process for cleaning brass, copper and zinc alloys before plating to provide better removal of oil, grease, smutty deposits and soap films to assure better plate adhesion is described in Oakite News Service, house magazine of Oakite Products, Inc. Bulletin De-296.

Rocker Barrels

The operation of cleaning miscellaneous items of gray iron, steel, semi-steel malleables, forgings, plate, bars, bronze and other castings by the Airless Rotoblast method is described fully in a handsome booklet by the Pangborn Corp. Bulletin Ae-68.

Cadmium Plating

Concise, practical information for the operating plater is included in an up-to-date manual on cadmium plating released by E. I. duPont deNemours & Co., Inc. Bulletin Hd-29.

Washing Problems

New, illustrated factual folder released by the Alvey-Ferguson Company depicts concisely how various product washing problems were solved with especially engineered Alvey-Ferguson super-spray product washing machines. Bulletin Ne-329.

Metal Progress, 7301 Euclid Avenue, Cleveland, O.
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Page 943				Page 944				Above			
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Na-141	Be-53	Ne-330	Ec-113	Ge-51	Le-66	Ke-5	Be-301	Cc-16	Kd-85	Ld-32	De-296
Kd-290	Ie-110	He-315	Gc-132	Da-70	Ie-213	Hd-271	Ne-86	Ke-92	Cd-255		
Ce-269	Be-22	Le-177		Ne-154	Ie-88	Ne-226	Ne-134	Ge-313	Be-8	He-90	Ae-68
Ke-55	Ie-320	He-316	Ke-118	Ec-203	Ie-319	De-100	Ke-239	Ne-173	Ge-311		
Ke-234	Ke-135	Ae-297	Ne-328	Ce-75	Ke-192	Ne-195	Ec-208a	Ne-71	Ce-76	De-307	
Ke-323	Ne-67	Ie-230		Be-30	Ke-324	Ne-114	Ec-215	Ne-165	Lb-52		Hd-29
Ne-49	Ne-3	Ee-170	He-24	Ce-219	Ke-226	He-96	Le-327	Ge-312	Ld-208	Ka-13	
Ne-38	Ne-21	Ie-318	Ld-57	Be-11	Ke-321	Ke-64	Ed-264	Kd-229	Kd-294		
				Nd-123	Ed-266	Ge-63		Kd-293	Ke-116	Kd-286	Ne-329
				Ge-218	He-46	Ke-126			Kd-233		

OXIDES ON HEAT RESISTING STEEL*

By A. G. Quarrell

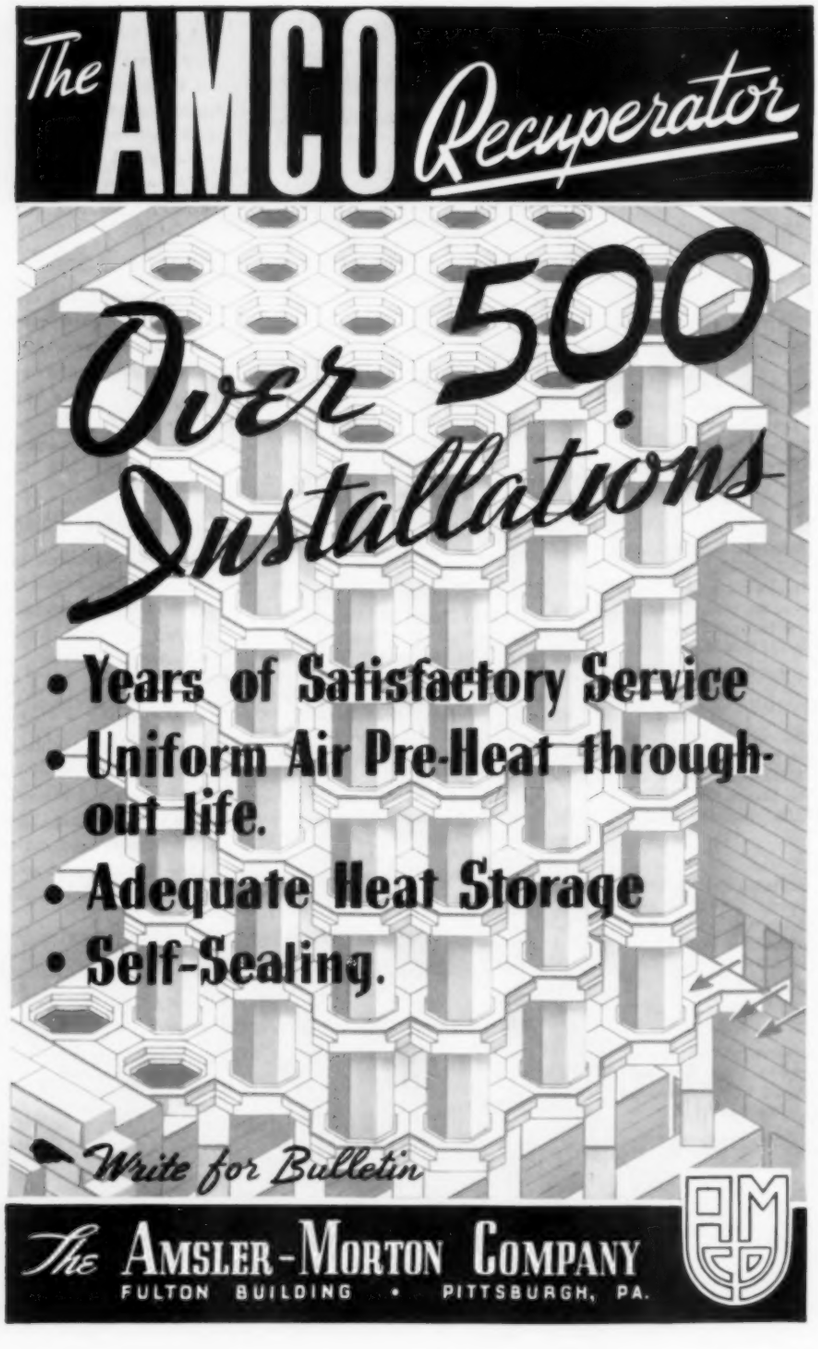
THE NEW technique of electron diffraction for examining iron oxide films was applied to a heat resisting steel of the following composition: C 0.47%, Mn 0.72%, Si 1.7%, Ni 12.9%, Cr 13.1%, Mo 3.1%. Whereas with ingot iron, 3 c.c. of air sufficed to form an oxide film which gave a well-defined diffraction pattern, at least 10 or 20 times as much was necessary with the heat resisting steel. At all temperatures of formation up to 1750° F. of films of various thicknesses up to that corresponding to 100 volumes of air, the oxide film corresponded to a spinel structure, but with very small crystal size.

The spinel structure with a complicated cubic unit cell is possessed by a large number of compounds. Moreover, their lattice parameters differ only slightly, and therefore it is not possible to decide from the data the exact nature of the compound, but it is not Fe_3O_4, since the experiments on ingot iron show that this is stable only below 800° F. and above 1600° F.

The spinel structure is possessed by a very large number of oxides of the type $XO.Y_2O_3$, where X is a divalent and Y a trivalent metal atom. The X position in the lattice may be shared by two or more metals, or the X atoms may even change places with those normally occupying the Y positions. Indeed, spinels have been observed in which the Y positions are all occupied by atoms which are normally regarded as divalent, e.g., $TiO.Zn_2O_3$ and $SnO.Zn_2O_3$.

The structure also seems to be very stable if such elements as nickel, chromium and aluminum are present in the Y position in sufficient quantities. Once it has been stabilized, the introduction of a new type of metal atom seems to cause no disturbance of the lattice structure. When both the X and Y positions are occupied by iron atoms the structure is less stable and the lattice can be converted to FeO. But with the more general type of spinel, containing at least two different metals, a corresponding change is impossible, and therefore the structure should be stable over a much wider range of temperature. *(Continued on page 954)*

*"Note on the Resistance to Furnace Atmospheres of Heat Resisting Steels", Paper for British Iron and Steel Institute, May 1941.



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HEAT RESISTORS

(Continued from page 946)

This stable spinel may be associated with the resistance to oxidation of heat resisting steels.

When pure iron is heated the oxide formed will consist of Fe_2O_3 but on the addition of increasing amounts of nickel and chromium the alloying elements stabilize the structure. The steel then shows considerable resistance to oxidation, although, of course, its mechanical properties at high temperatures may not be satisfactory, and it may be necessary to add other alloying elements. But any metal used or likely to be used as a strengthener can take up either the *X* or *Y* position in the spinel lattice, and it is at least highly probable that, once the spinel has been stabilized, it can accommodate any of the common metals.

Mixed sulphides also form spinels. It seems likely that the film formed on steels in furnace atmospheres containing sulphur will be a mixed sulphide-oxide spinel. It is possible that this spinel can also accommodate the oxygen and sulphur in the proportion in which they occur in the furnace gases. Changes in the gas composition could be counterbalanced by the interchange of sulphur and oxygen atoms. The spinel then could maintain equilibrium with the atmosphere of the furnace without breaking up or allowing excessive corrosion.

The stable spinel, whether oxide or oxide-sulphide, could contain a large proportion of iron, provided sufficient alloying constituents were present to prevent the reversion to FeO on cooling. The stability of the spinel at high temperatures would be determined by its composition, and it is from this point of view that the composition of a heat resisting steel may possibly be critical in so far as oxidation resistance is concerned. Steels containing aluminum may owe their corrosion resistance to a particularly stable spinel.

Protective oxide films are invariably amorphous or have a very small crystal size. Many heat resisting alloys contain silicon, and it is known that the amorphous silica film is quite protective and is stable even at very high temperatures.

The composition of the oxide film on a heat resisting steel will depend, then, upon the composition of the steel and no exact formula corresponding to $FeO.Fe_2O_3$ can be assigned to it. Its oxidation resistance is proportional to the stability of its spinel lattice structure. The absence of lattice changes on heating and cooling will prevent easy access of oxygen through newly formed cracks to the underlying metal surface.

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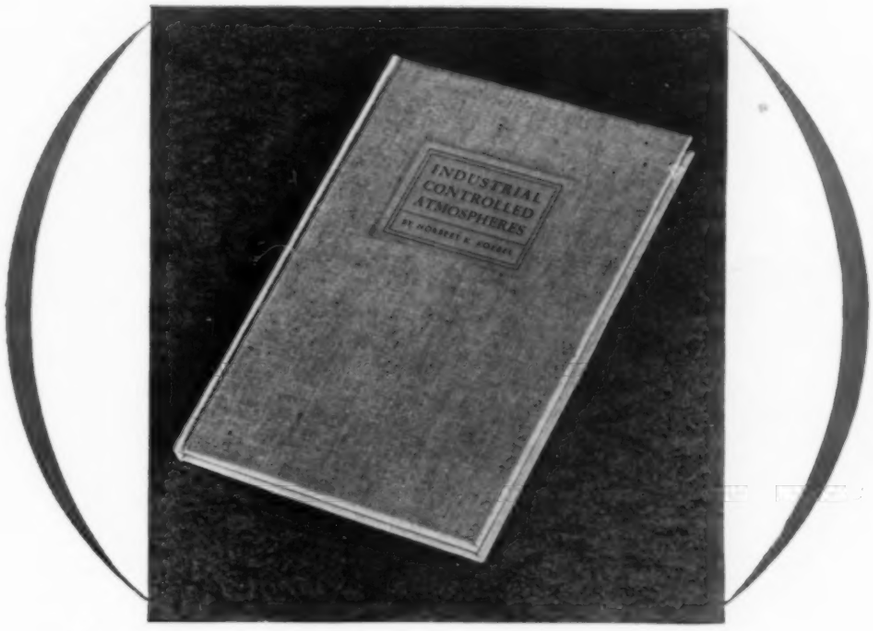
Second Edition—Revised and Enlarged—Indexed



By NORBERT K. KOEBEL

Research Director, Lindberg Engineering Company

HERE IS THE BOOK for all heat treaters and metallurgists who are interested in keeping up to date on the subject of controlled atmospheres. The author, a graduate of Ohio State University, later worked as a fellow at Battelle Memorial Institute on Atmosphere Control Research, and was for 5 years Metallurgist at Eastman Kodak Company, Camera Works, Rochester, N. Y.

It was in connection with his Atmosphere Control Research work that Mr. Koebel developed the Weight Change Method for checking effects and efficiencies of various atmospheres, a method that has since been adopted as a standard means of determination. This method is fully described in "Industrial Controlled Atmospheres" so that the metallurgist and heat treater can put it to work.

The Seven Chapters of the book include, "History of Controlled Atmospheres, Evaluating Controlled Atmospheres, Older Methods of Atmosphere Control, Necessity for Better Atmospheres, Theory of a Good Atmosphere, Scale-Free Atmospheres, and Relation of Furnace Design to Atmosphere."

The book has received wide comment for the clarity with which the various methods are explained. It was originally published serially in The Iron Age. It includes also the outstanding paper on Methods of Determining Carburization and Decarburization presented by the author as part of the Controlled Atmospheres Symposium at the 1941 A.S.M. Convention at Philadelphia.

There are seven chapters, 28 illustrations and 100 pages. Bound in an attractive and durable cloth over boards, gold stamped. Dimensions are 6½" x 9½". The price is $1.00 postpaid, and your copy will be sent promptly upon receipt of remittance. Please print name and address clearly.

CONTENTS

1. History of Controlled Atmospheres
2. Evaluating Controlled Atmospheres
3. Older Methods of Atmosphere Control
4. Necessity for Better Atmospheres
5. Theory of a Good Atmosphere
6. Scale-Free Atmospheres
7. Relation of Furnace Design to Atmosphere

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FRICTION PHENOMENA*

By F. Morgan, M. Muskat and D. W. Reed

STUDIES of stick-slip behavior have recently been made by BOWDEN and collaborators using an apparatus with an elastic friction measuring element possessing a high natural frequency of vibration. A high frequency spring system was used for applying the load to a flat plate which could be driven at a slow and uniform velocity.

When the plate was set in motion the slider was observed to move along as though the two had stuck together until the restoring force of the spring became sufficient to jerk the slider loose and bring it back into position to stick again. It appeared that the actual temperatures might be much higher than the measured values, and melting temperatures were considered to be a distinct possibility. Local welding was thus postulated, and the observed stick-slips were explained as being the manifestation of this welding and the subsequent rupture of the contacts.

Further studies were undertaken by the present writers using a similar apparatus consisting of a slowly rotating table and a slider elastically supported. The motion of the slider is photographed by a light beam reflected from a lens and mirror combination.

The elastic friction-measuring spring must be calibrated by applying a known force to the slider and measuring the deviation of the spot of light. The static friction is then equal to the force required to give the slider a displacement equal to that at which sliding begins.

The coefficient of kinetic friction is not as easily determined as the static coefficient. According to the method adopted by BOWDEN and LEBEN it will simply be the value obtained by dividing the force corresponding to the average displacement of the slider by the load. If the conventional definition of kinetic friction is assumed, however, it is necessary to have additional information on the inertia and damping of the moving system. The present authors have used stretched-out curves of the slip portion of the cycle from which it is theoretically possible to determine the usual coefficient of kinetic friction. *(Cont. on p. 962)*

*(Abstracted from "Studies in Lubrication; X. Friction Phenomena and the Stick-Slip Process", published in *Journal of Applied Physics*, Oct. 1941, p. 743.)

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FRICTION

(Continued from page 958)

Experiments have been conducted with moving surfaces of various metals. Most of the experiments on steel were performed on plates of about 200 Brinell. The surface finish has been varied from relatively rough to "mirror smooth" with no appreciable difference in the type of sliding.

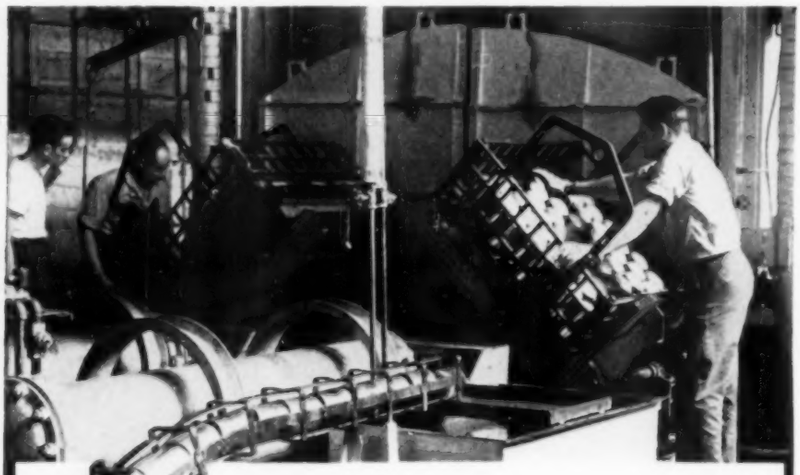
For temperature measurements a constantan slider has usually been used in conjunction with a steel or brass plate.

In tests made of Wood's metal sliding on babbitt, the coefficient of static friction, as determined by the average maximum displacement of the slider, was about 0.8 for loads of 400 and 450 g., and 1.0 for loads of 250 and 275 g. The lack of uniformity in the maximum displacement of a given series is sufficient evidence of the importance of the role played by the surfaces themselves. Actually each stick and slip cycle may be regarded as a separate experiment in itself.

With constantan sliding on steel the coefficient of static friction was about 0.6. A short slip, which occurred during the first period, is an example of an irregularity that has been found to occur much more frequently when both surfaces are hard materials than when either component is a soft metal. Differences in the type of sliding are undoubtedly responsible for the changes observed. The softer metals flatten out more when under load and make more intimate and regular contact.

Temperature jumps or flashes occur only during relative motion, as may be expected. The observed temperature rise depends upon the metals comprising the junction, the load, the velocity of the table, and the characteristics of the friction-measuring element. However, in none of these experiments at low table velocity has a temperature flash of more than 50° C. above ambient been observed. High temperatures are, of course, produced even at moderate loads when the velocity becomes so large that the heat cannot be removed as fast as it is generated.

Since an insight into the behavior of the coefficient of kinetic friction as a function of velocity can be obtained in these experiments only by an analysis of the backward motion of the slider, it obviously was necessary to modify the experimental technique so as to obtain good traces of the slip even at the expense of the stick line. Such analysis is possible with very high camera speeds, and thus both static and kinetic friction data can be obtained from a single stick-slip cycle.



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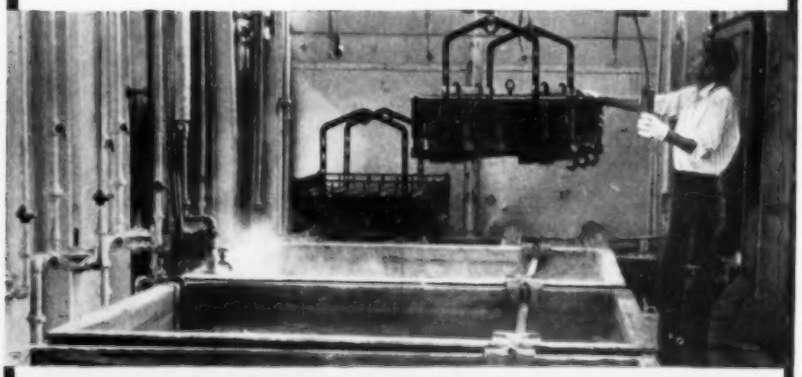

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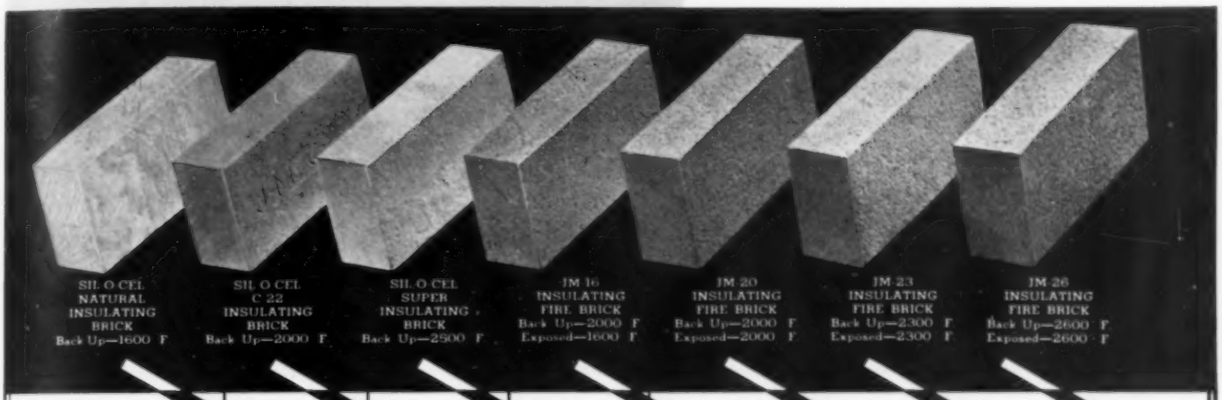
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Linear Shrinkage—%	1.4 @ 1600° F	0.8 @ 2000° F	2.0 @ 2500° F	0.0 @ 2000° F	0.0 @ 2000° F	0.0 @ 2300° F	0.5 @ 2600° F
Reversible Thermal Expansion—Percent	0.1 @ 1600° F	0.7 @ 2000° F	1.29 @ 2000° F	0.5—0.6 @ 2000° F	0.5—0.6 @ 2000° F	0.5—0.6 @ 2000° F	0.5—0.6 @ 2000° F
Conductivity at Mean Temperature	∥ ⊥						
500° F	1.01 .67	1.67	1.70	.75	1.01	1.26	1.61
1000° F	1.13 .79	1.88	1.95	1.01	1.19	1.49	1.90
1500° F	1.24 .90	2.08	2.19	1.41	1.49	2.05	2.61
2000° F	... ..	...	2.45	...	1.91	3.37	4.29
Recommended Service							
Back Up	1600° F	2000° F	2500° F	2000° F	2000° F	2300° F	2600° F
Exposed	....	....	....	1600° F	2000° F	2300° F	2600° F
Recommended Mortar for Setting Brick	Sil-O-Cel Mortar	Sil-O-Cel Mortar	Sil-O-Cel Super Brick Mortar	J-M No. 1626 Cement	J-M No. 1626 Cement	J-M No. 1626 Cement	J-M No. 1626 Cement

Note:—1. Above tests are in accordance with ASTM tentative standards.
2. Conductivity is expressed in Btu. in. per hr. per sq. ft. deg. F. at the designated mean temperatures.
3. ∥—with heat flow parallel to brick strata.
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STIFFNESS OF HOT CAST IRON*

By L. W. Bolton

ORDINARY gray cast iron fails at high temperature through growth and scaling, but special irons have been developed in recent years to overcome both these effects. The resistance of these special irons to deformation under prolonged application of light loads at high temperatures is described in this report. Furthermore, the effects of graphite size, variations in silicon and phosphorus content and of austenitic structure were studied.

A method of testing was developed in which a bar of standard dimensions was rigidly held at one end, while the other end was loaded, the stressed portion of the bar being held at a constant temperature of 1560° F., and the deflection of the free end recorded. Tests were continued until the bar had bent through an angle of approximately 10°. It is worthy of note that even the most brittle of cast irons, such as the high silicon and high phosphorus irons, were found to deform to this extent at 1560° F. without breaking. Test pieces machined from thick cast sections were less rigid than those machined from thin sections of the same iron.

Results of tests on bars containing 2 to 14% of silicon showed that additions of more than 7% silicon considerably increase the resistance to deformation under load at high temperatures.

The effect of phosphorus on cast irons of low (3.2%) and of high (5.5%) silicon content was studied. In both cases additions of phosphorus were found to increase the resistance of cast iron to deflection, particularly in the higher silicon irons. However, the phosphide eutectic melts about 1770° F., and at temperatures of this order the presence of relatively small quantities of phosphorus is sufficient to cause almost complete loss of mechanical strength.

In order to examine the influence of graphite size, bars were cast in two different sizes from four different compositions. In each melt the bar cast to the larger original diameter contained graphite in larger flakes than the bar cast smaller, and in each cast the smaller bar resisted deflection at 1560° F. better than

(Continued on page 970)

*Abstracted from "A Study of Some of the Factors Affecting the Resistance of Cast Iron to Deflection Under Load at High Temperatures", Advance Paper for British Iron and Steel Institute, May 1941.

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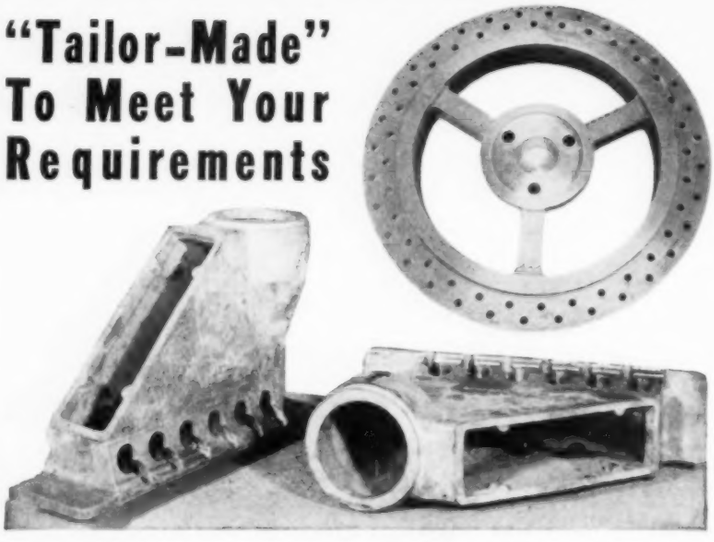

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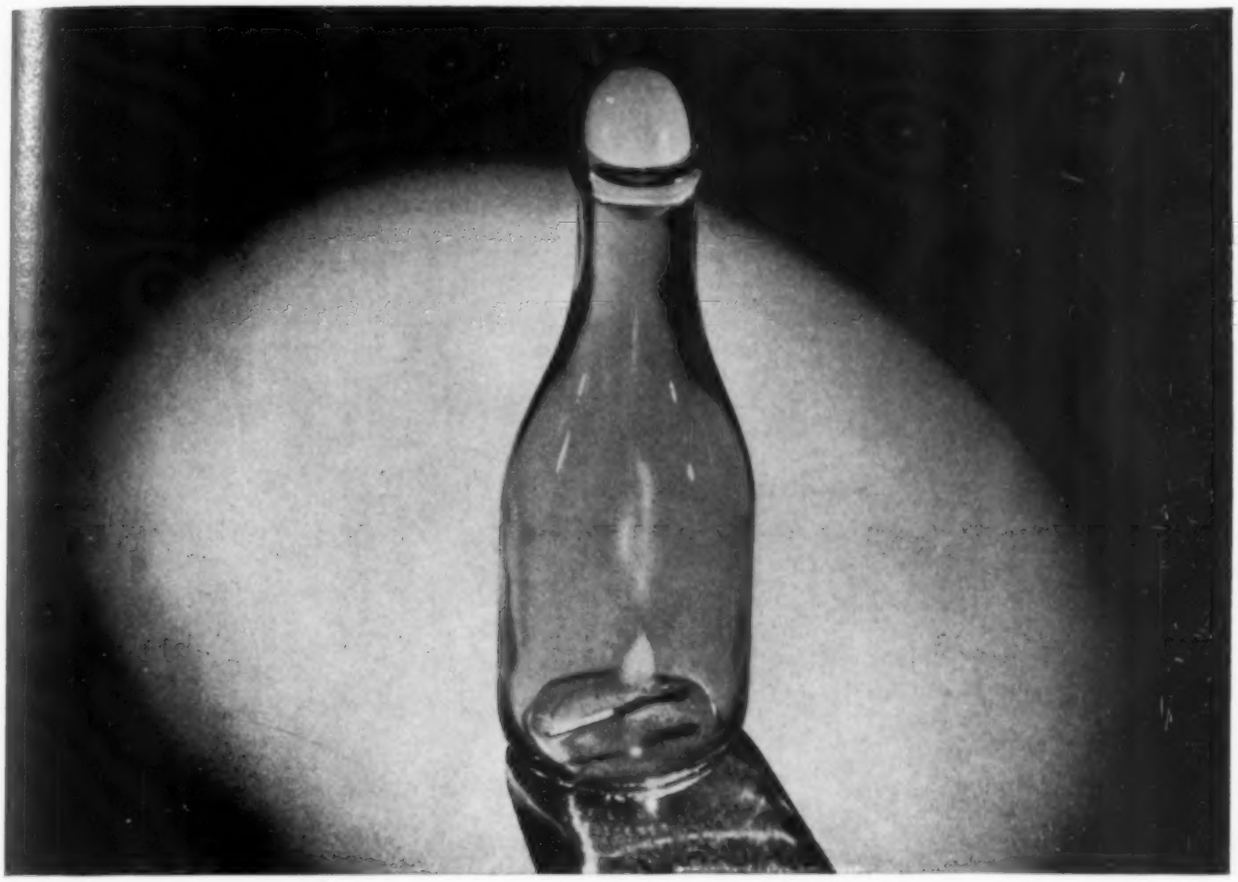

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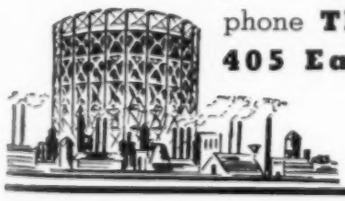

KEMP of BALTIMORE

CAST IRON

(Continued from page 966)

the larger bar. Large diameter, high phosphorus bars were more rigid than the large diameter, low phosphorus bar, showing that the phosphorus has a stiffening influence, even in large sections. While the higher silicon bars were stiffer than the lower silicon ones of the same as-cast size, the lower silicon 0.65-in. diameter as-cast bar was stiffer than the higher silicon ½-in. diameter bar.

These tests show that, for the same composition, a cast iron with coarse graphite has less resistance to deflection at high temperatures than an iron containing fine graphite. Both silicon and phosphorus increase the stiffness of coarse graphitic cast irons at the temperature of the tests. However, small differences in graphite size are unimportant and have less influence on resistance to deformation at 1500° F. more or less, than relatively small changes in composition. An increase of 0.5% silicon, or of 0.17% phosphorus, more than offsets the influence of the coarser graphite structure. But large differences in graphite size have a greater influence on rigidity than comparatively large differences in composition. It would appear necessary that gray cast iron for high temperature service should have a fine graphite structure.

Three plain carbon steels of various carbon contents were tested to obtain a comparison between their resistance to deflection at 1560° F. and that of cast iron. The 0.80% carbon steel deflected considerably more than any of the cast irons tested, with the exception of those with very coarse graphite structures (large diameter bars). The medium carbon steel (0.40% C) has a resistance to deflection comparable with that of a cast iron containing 5.75% of silicon in a 0.65-in. bar.

The most important of the recently developed heat resisting cast irons are the highly alloyed austenitic irons known as Ni-Resist and Nicrosilal. Two irons of each type, with high and low chromium contents, were tested. The higher chromium bars of each type are more rigid than those lower in chromium. The higher silicon material offers a greater resistance to deflection than lower silicon bars, in both high and low chromium irons.

Irons of the high chromium, high silicon type should be well annealed at a temperature of 1550 to 1650° F. before being put into service. These tests also show that austenitic high silicon-nickel irons are more rigid than austenitic copper-nickel irons when hot and chromium additions increase the stiffness of austenitic cast irons at 1560° F.

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KEEPING "BUGS" OUT OF BRASS. In the making of brass and other copper-base alloys, Revere adds a vital ingredient—the *human touch*—that has a way of producing better metals. Behind each operation is a trio like Arthur Bower, Harry Schagrin and Alfred Roy, which combines the experience of a foreman, the knowledge of an engineer, and the skill of an able craftsman. Methods, supervision, operation, each is in very capable hands. It is such teams as these that keep "bugs" out of Revere metals . . . making them *right* for the needs of Defense today, and preparing well for the new needs of tomorrow's revived industry. Revere Copper and Brass Incorporated, 230 Park Avenue, New York.

★ ★

SOLIDUS

(Continued from page 905)

and that all the liquid solutions were equally identical. There is, however, at least a possibility that the dissolved carbon may be present either as the element or as the carbide.

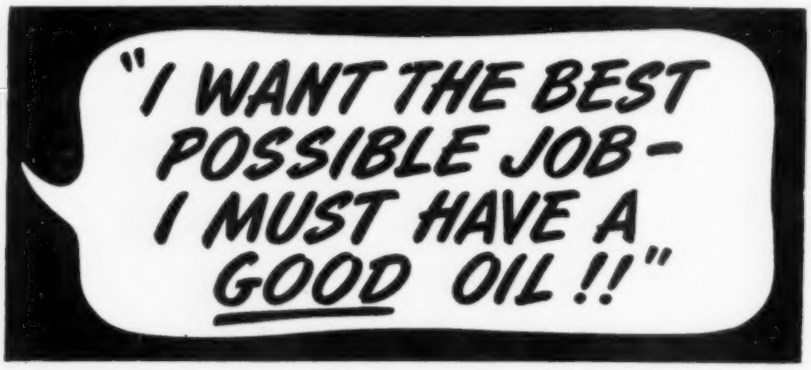
It is undoubtedly true that for true equilibrium some particular degree of dissociation of iron carbide should establish itself, and that a single diagram should be drawn having reference to the particular degrees of dissociation in the two solutions which represent the equilibrium state. By the same token the diagram should not contain any lines bearing on the system iron-cementite, for quite obviously, since cementite in the solid state is metastable, the black lines of the diagram in METAL PROGRESS represent only metastable equilibrium. For reasons of convenience, however, for many years a double iron-carbon diagram has been found a useful thing in the interpretation of phenomena. It should, therefore, be permitted also to consider the possibility of two solid solutions and two liquid solutions in studying the region of the diagram where equilibrium between the solid and liquid phase is involved.

Experimental justification exists in the circumstance that quite competent investigators have not agreed upon the location of the solidus line; a number of individuals check each other for each of the two lines commonly included in the diagram. As remarked above, this difference in the experimental location of the solidus line could be explained by the difference of the degree of dissociation of carbide.

Space scarcely permits an extended discussion of this subject, but the details of the experiments used, for example by CARPENTER and KEELING and by HONDA (whose results are typical respectively of those for the two different solidus lines) make it possible that one of them represents practically complete dissociation of carbide, the other incomplete dissociation. There is much room for difference of opinion and argument, and those who may desire to make up their own minds for themselves can find the thermodynamic reasoning in an article by KÖRBER and OELSEN published in *Archiv für das Eisenhüttenwesen*, Vol. 5, 1932, pages 569 to 578. The article was extensively reviewed with some original comment by J. B. AUSTIN in *Metals and Alloys*, Vol. IV, 1933, page 49.

The present writer's opinion is that the best evidence requires the assumption that cementite can be present in solid and liquid solutions in various degrees of dissociation.

HARRY A. SCHWARTZ



"THAT'S WHY I CALLED THE CITIES SERVICE LUBRICATION MAN IN" SAYS A. E. DAVEY, PRESIDENT OF ALLOY STEEL GEAR AND PINION COMPANY OF CHICAGO.

"I'm doing a job here that must be perfect when it leaves the shop. The people who get the gears are plenty critical." Mr. Davey says further, "I don't know everything about oil. That is why I called in the Cities Service Lubrication man. I expect him to work with my men to see that they get the oil best suited for the job."

A. E. Davey

Much work in this shop must meet rigid government inspection. All Gleason, Fellows Gear Shapers, Lee Bradner and Brown & Sharpe machines, are operated with Cities Service Lubricants. You, too, will find these high-quality fluids capable of doing the kind of work your customers want.

Call us in for consultation — there is no charge for the service. Write us on your letterhead or mail the coupon for a copy of our booklet, "Metal Cutting Lubrication."

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HEAT TREATING

Old man "Reject" is a master saboteur. And when he steps in at the heat treating stage—he wrecks hours of forging, casting and machining time.

The even, well distributed and controlled heats in modern furnaces practically eliminate "Rejects". Even the art of loading has been improved to obtain bigger batches, with conveyor loading and complete atmospheric control. The amount of floor space required is frequently reduced.

The Spencer Turbo-Compressor, a reliable source of clean air at correct pressures without surges, has contributed greatly to the art of heat treating small parts.

This series of advertisements pictures applications of Spencer Turbos made by 20 leading furnace and oven manufacturers. Ask them about your heat treating problems and the Spencer Turbo.

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Machine Parts

Rotary hearth normalizing furnace. Heating starter rings.
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Three rotary drum type furnaces for heat treating and drawing lock washers. CLAUD S. GORDON CO.

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35 to 20,000 cu. ft.
1/3 to 300 H.P.
8 oz. to 5 lbs.

THE SPENCER TURBINE COMPANY • HARTFORD, CONNECTICUT

DIE CASTINGS

(Continued from page 903)

casting practice will probably explain this discrepancy when a complete story is available. New Jersey Zinc Co.'s results also indicate some difference between Alloy No. XXV and the 1.5% aluminum alloy but the results are too incomplete to say whether the difference will be objectionable. It further reports that to retain as favorable a comparison with the specification alloy as above, a low-aluminum substitute for Alloy No. XXIII (4% Al, 0.03% Mg) must contain at least 2.0% aluminum.

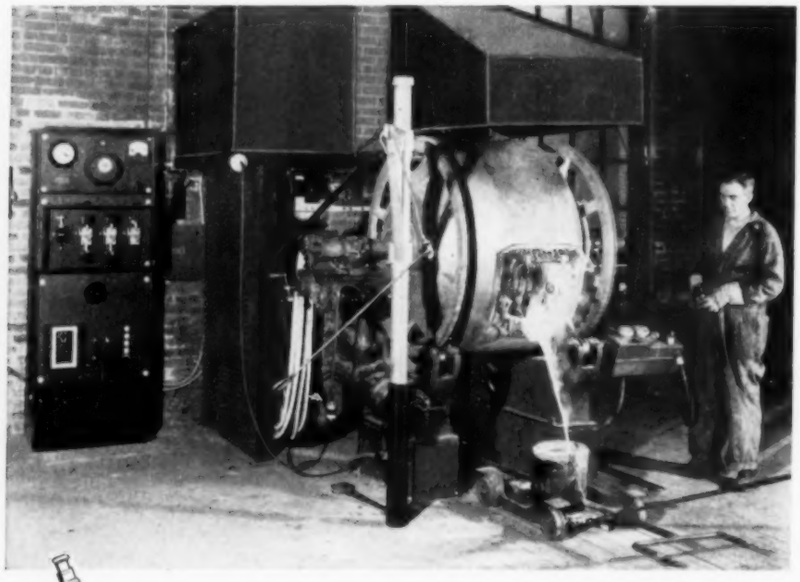
This information, *whose incomplete character cannot be too strongly emphasized,* has been reviewed and is presented here, briefly, for the information of producers and consumers of zinc die castings. There is no assurance at present that properties on which tests are not yet available may not interfere with the use of these alloys in some instances, at least, just as difficulties with casting properties have already come to light as commercial trials have followed the laboratory tests.

Attention is drawn to the following points on which information is lacking or incomplete: *(a)* The range of permissible die and metal temperatures has not been determined. Some alloys of this type have been previously encountered which permitted too narrow a range for commercial operation. *(b)* Creep resistance, which is a property of governing importance in many uses, particularly where slightly elevated temperatures are encountered, has not been determined.

Varying reports have been heard concerning the experiences of die casters attempting to use these alloys. Some difficulties have been encountered due to the difference in solidification shrinkage characteristics and greater hot shortness of the lower aluminum alloys. In some instances, these difficulties have been overcome by increasing the aluminum content from 1.5 to 2%. To what extent these difficulties can be overcome by attention to die design and casting practice is not yet known.

To summarize, then: In spite of the probability that a large number of castings can be successfully made with these alloys, the available evidence indicates that, due to the above difficulties, some castings cannot be produced successfully with alloys of reduced aluminum content. (This represents the considered opinion of Sub-Committee II of Committee B-6, of which the undersigned is secretary.)

BERT E. SANDELL
Metallurgist and Chief Chemist
Stewart Die Casting Division
Stewart-Warner Corp.



Precise Metallurgical Control plus High Speed Production

For close chemical and metallurgical control in the melting of either Ferrous or Non-Ferrous metals or alloys the Detroit Rocking Electric Furnace cannot be surpassed. Its exclusive automatic stirring action under non-oxidizing conditions, and the precise control of time, temperature and composition make this quality control possible.

The Detroit Furnace is a fast melting unit. With it, the jobbing or production foundry can produce a great number of heats—large or small—in rapid succession 8, 16 or 24 hours a day

The Detroit Furnace is flexible, versatile, and economical.

Write today for further facts about this remarkable foundry production unit or better still let us arrange for you to see a few of these furnaces in operation and talk to their owners yourself. Get the low-down first hand from those who know.

DETROIT
ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY
BAY CITY, MICHIGAN

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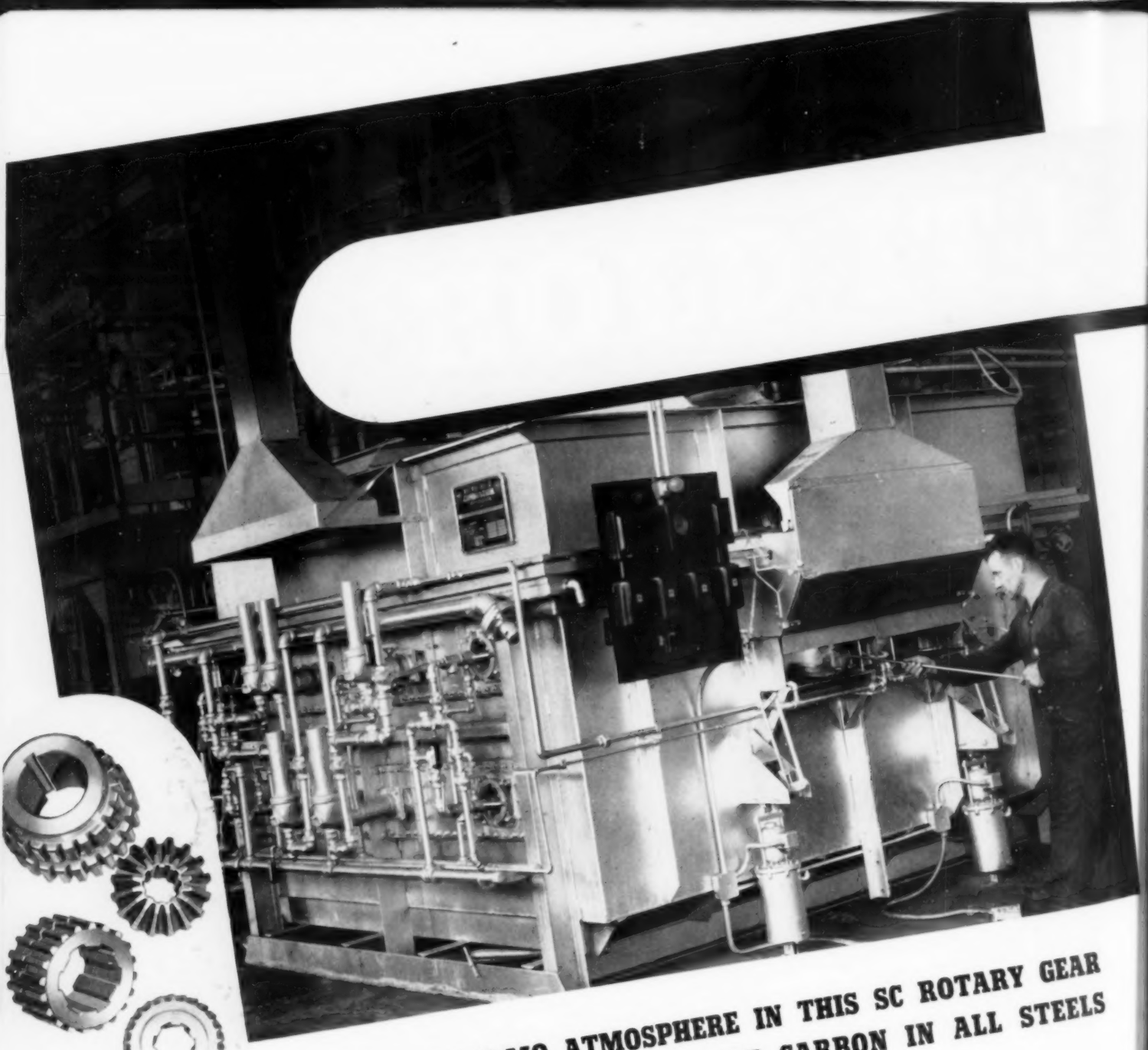
METAL PROGRESS

DECEMBER
1941



THE NEW CHAR-MO ATMOSPHERE IN THIS SC ROTARY GEAR HARDENING FURNACE HOLDS THE CARBON IN ALL STEELS

● Holding or retaining the carbon in carburized gears during the hardening operation has always been a problem to contend with. Shown here is a new controlled atmosphere rotary hearth furnace (with square walls) developed for a leading gear manufacturer in Cleveland, Ohio.

Heated by means of gas-fired radiant tubes, this furnace utilizes the recently developed SC Char-Mo Atmosphere. Consisting of approximately one-third carbon monoxide and two-thirds nitrogen—with only slight traces of carbon dioxide and water vapor—this atmosphere is inert to high carbon steels. Where desirable, Char-Mo Atmosphere can even be made to carburize.

To test the effect of the atmosphere, bars of 1% carbon were ground and subjected to a cycle of 48 minutes in this furnace. Three cuts were made and analyzed for carbon. The first cut (.0025" deep) showed a carbon content of 1.15%; the second cut (.005" deep) 1.03% C., and third cut (.010" deep) .996% C. This test indicated a slight surface carburization which was desirable in this case.

On request we shall be glad to send you bulletin SC-96A giving operation data on this and other rotary furnaces.

SURFACE COMBUSTION CORPORATION · TOLEDO, OHIO

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MANUFACTURERS OF INDUSTRIAL FURNACES · JANITROL GAS-FIRED SPACE HEATING EQUIPMENT · AND KATHABAR AIR CONDITIONING SYSTEMS

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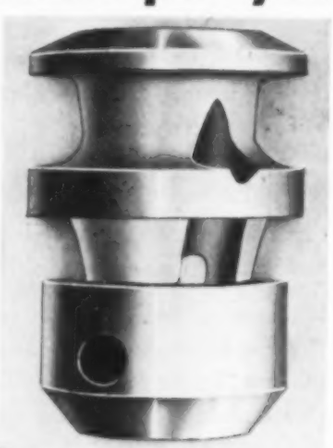
TOCCO speed boosts hardening output 600%

. . . Elimination of rejects saves $7300 per year

● Two years ago, The Jacobs Manufacturing Company installed an early model TOCCO Jr. to harden drill chuck bodies . . . to increase hardening speed and eliminate distortion and rejects caused by the former process.

With chucks used extensively in aircraft plants and other defense industries, Jacobs production has jumped 600%. To meet this demand, the plant recently installed a larger, more modern TOCCO Jr. It is hardening chuck bodies at a rate which represents a 60% gain over the first TOCCO Jr. . . . and a 600% gain in output per operator-hour over the former process. And it saves more than $7300 per year by elimination of rejects due to distortion.

Why not find out how the TOCCO process for hardening and heating of parts can increase your production speed, improve your products and cut your costs. The services of our engineers are yours for the asking.



Irregular shape of chuck body caused serious distortion with former hardening process which heated whole front end. TOCCO heats up and hardens only the nose and wrench holes, the wearing areas. Eliminates distortion and rejects. Courtesy of The Jacobs Manufacturing Co., Hartford, Conn.

THE OHIO CRANKSHAFT COMPANY
Cleveland • Ohio

TOCCO
World's fastest, most accurate heat-treating process

Here's how to Build Better Banks and Save Time, Too!

ILLUSTRATED here is an improved way to install open hearth banks of Ramix. This new method speeds up ramming and results in better front, back and end walls.

Wooden forms, quickly erected after the bottom is rammed, serve to retain the Ramix as it is installed behind them. The practical value of the forms, as shown on several recent sub-hearth jobs, is as follows:

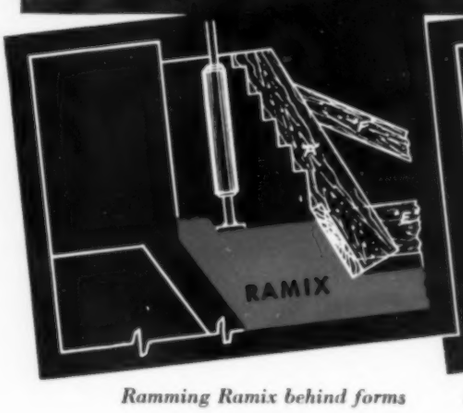
1. Walls are built to accurate, uniform dimensions, since height, thickness and slope are determined by the pre-set forms.

2. Ramix consolidates quickly and completely into a dense, monolithic bank integral with the bottom, because of more effective ramming in a confined area with the hammer held steadily in a normal vertical position.

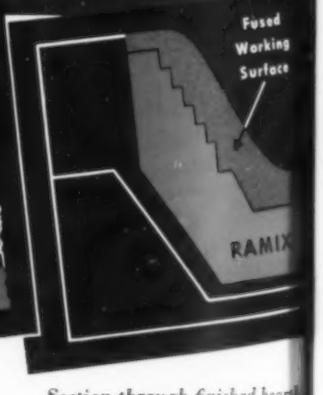
3. Bank ramming proceeds very rapidly—as fast as moistened Ramix can be shoveled into the forms.

4. The uniform corbelled, or terraced, contour produced by the edges of the forms facilitates the burning in of the fused working surface and results in a more symmetrical finished hearth.

Equally valuable for new construction and repair, Basic Refractories, Inc. recommends this new system of bank construction as a further safe means of saving time and labor in the present emergency. We shall be glad to furnish drawings, as well as to assist in the installation or repair of hearths with Ramix, in both open hearth and electric furnaces.



Ramming Ramix behind forms



Section through finished hearth

Basic Refractories for the Steel Industry:

MAGNEFER —Dead-burned dolomite for hearth and slag line maintenance.

SYNDOLAG —Dead-burned dolomite, smaller in grain size than Magnefer.

BASIFRIT —Quick-setting magnesia refractory for new construction, resurfacing and general maintenance.

GUNMAG —A magnesite-bonded refractory sized for use with a cement gun, especially for basic electric furnace walls.

RAMIX —An air-setting basic refractory for rammed hearths and cold furnace repairs.

695 PLASTIC —Strong plastic with basic and neutral properties, for hot and cold repairs.

OHIO MAGNESITE —Domestic dead-burned high-magnesia grain refractory, equal to Austrian.

HEARTH PATCH —For deep hole patching and other quick repairs in the basic open hearth.

BASIC REFRACTORIES, INC.
FORMERLY BASIC DOLOMITE, INC.

CLEVELAND, OHIO

Morse Improves Heat-Treatment by Using Micromax Pyrometer

Sensitive and accurate control of temperature is of course not new to the Morse Twist Drill & Machine Co., but it is more easily secured now than ever before, in the heat-treatment of high-speed steels, because the Company is using a Micromax Pyrometer, with a Rayotube as temperature detector.

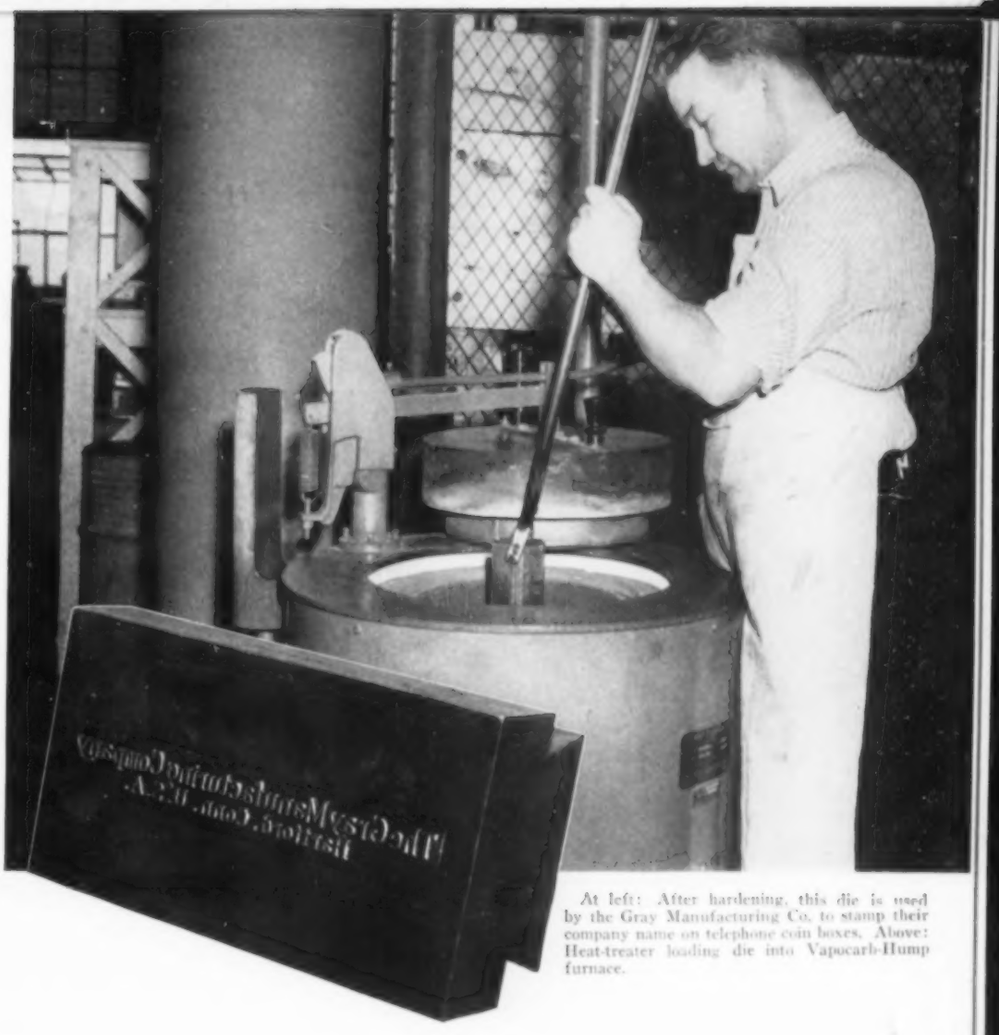
Milling cutters and similar tools are preheated before they enter the Company's Hayes high-speed-steel furnace, which the Micromax is holding constant at the high hardening temperature. A batch of 6 tools, plus this holder, weighs only a few pounds. Nevertheless, when it enters the furnace, the Micromax pyrometer is so sensitive that its record actu-

Foreman examining record of Micromax Recording Controller. Below is full-size sample of record, showing "spikes" caused by putting batches of drills into furnace. Note sensitivity and speed of control.

ally moves off at a right angle; it seems almost to jump. And the instrument simultaneously calls for more heat energy. As temperature rises in response to this call, the Micromax watches carefully, and shuts down on the supply in such a way as to return temperature to the control point with promptness and precision. So successful is the control that rejects due to heating are almost unknown.

As the chart shows, the cycle of off-temperature-and-back is controlled so quickly and accurately that it's represented by a single sharp spike on the record. Each spike thus indicates one batch of tools "signing" into the furnace, automatically, for accurate heat-treatment. The record guides both heat-treater and foreman, and is always ready to help convince either management or customer of the quality of heat-treatment.

The Micromax sensitivity and responsiveness, which perform somewhat spectacularly here, are available for any type, size or make of furnace, or almost any other heat-using equipment. If you have a temperature-control problem, outline it and we will send the appropriate catalog.



At left: After hardening, this die is used by the Gray Manufacturing Co. to stamp their company name on telephone coin boxes. Above: Heat-treater loading die into Vapocarb-Hump furnace.

FINELY-ENGRAVED DIES
Deserve Vapocarb-Hump Hardening

The question of how to handle this die in the hardening furnace might well be a problem in many heat-treats. Its original dollar-a-pound cost, for the steel, was of course redoubled several times as highly-skilled die sinkers labored over it, so that a bit of uneasiness as to furnace operation might well have been expected.

But that wasn't the case with this tool. The Gray Manufacturing Company, makers of telephone coin-boxes, use the Vapocarb-Hump hardening method on all tools like this, and there's no reason for uncertainty in such cases.

For the heat-treater has, in the Vapocarb-Hump Method, everything he needs to assure successful handling of the die in the furnace. He can shut the air away entirely, by means of Vapocarb atmosphere, thus eliminating all possibility of scale, pits, soft spots, and decarburization. He can see the temperature of the die, the temperature of the furnace, and the difference between them, and can control this latter to prevent warp. And the die itself will tell him when it enters the critical, and when it leaves, so that he can decide just when to quench it to secure the desired depth of hardness. Undaunted by the high value of the tool, the heat-treater can thus proceed to harden it so as to give it the longest possible life—many years, in this case.

If your plant suffers from erratic performance of tools—even of low-priced ones—Vapocarb-Hump hardening can probably help you. Ask for Catalog T-621.

Ind Ad ENT-0600C(35)

LEEDS & NORTHRUP COMPANY, 4927 STENTON AVE., PHILA., PA.

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MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

NO. 9

ALUMINUM, DEFENSE, AND YOU

SIX MORE PLANTS IN FIVE STATES ON THE WAY

DEFENSE PLANT CORPORATION OWNS THEM. We've been designated to build them . . . fast.

Actually, when the names went on the dotted lines of the contract on August 19, we had already placed more than $16,000,000 worth of orders for some of the equipment and materials it takes longest to make and get.

FIVE OF THESE PLANTS will smelt aluminum. Their combined capacity is planned for more than 500,000,000 pounds a year, which is greater than the nation's entire production of aluminum in 1940. Locations: Massena, N. Y., Spokane, Wash., Troutdale, Ore., Los Angeles, and in the State of Arkansas.

The sixth plant will refine alumina from bauxite. Its billion-pounds-a-year capacity adds 58% to the nation's alumina capacity. It will be located at Bauxite, Arkansas.

HOW GOES CONSTRUCTION? At this writing, as fast as title is secured to the sites, contracts are being let for grading and foundations so as to be ready for the structural steel, which is coming as rapidly as it can be gotten.

What is more important, the aluminum plants are scheduled to deliver ingot by the summer of 1942: the refining plant to deliver alumina in early summer, 1942.

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WE'VE ASSIGNED a large staff of men full time to headquarters engineering, purchasing, and accounting on this government building job.

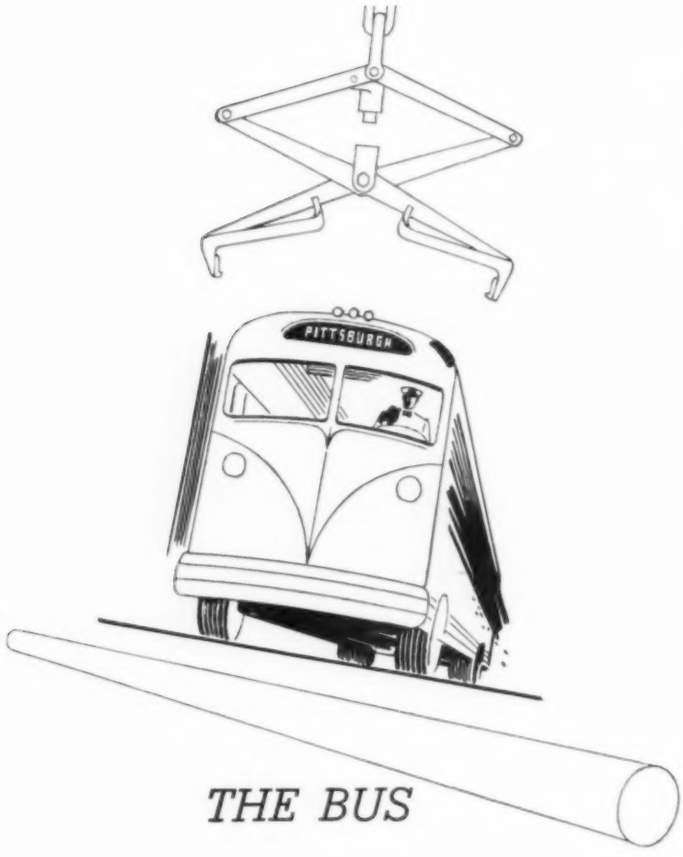
We're sending competent and experienced management men out on these jobs as superintendents and other staff executives on construction, and for subsequent operation of such of these plants as we are designated to operate.

EVERY KNOWN IMPROVEMENT in design and construction and equipment is being incorporated in these plants. We intend that every dollar that will be spent shall be the best dollar's worth that experience can build. We do not make one cent of profit from this assigned job of construction.

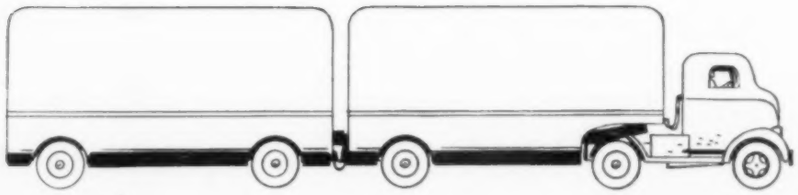
We think we know how to get the government value-received for its money, because we are completing the expenditure of more than $200,000,000 of our own money in an expansion program which started after the beginning of the present war. Some of this expenditure is in new alumina and aluminum plants which will bring our own Alcoa capacity up to more than 700,000,000 pounds a year. The remainder is in tremendous expansion of facilities for fabricating every form of aluminum.

DEFENSE, GENTLEMEN, is getting its aluminum.

ALUMINUM COMPANY OF AMERICA



THE BUS



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THE WILL TO MAKE GOOD STEEL

MAKING the kind of steel our country demands for its defense program requires a thorough knowledge of the steels needed, an organization of skilled steel makers, the best of steel making equipment, and — above all — the W I L L to make good steel.

The Copperweld Steel Company is producing the following Aristoloy Steels particularly for National Defense: RIFLE AND GUN BARREL QUALITY, GUN QUALITY, SHOT QUALITY, BULLET CORE AND AIRCRAFT QUALITY.

"SPECIAL QUALITY" TOOL AND ELECTRIC FURNACE ALLOY STEELS

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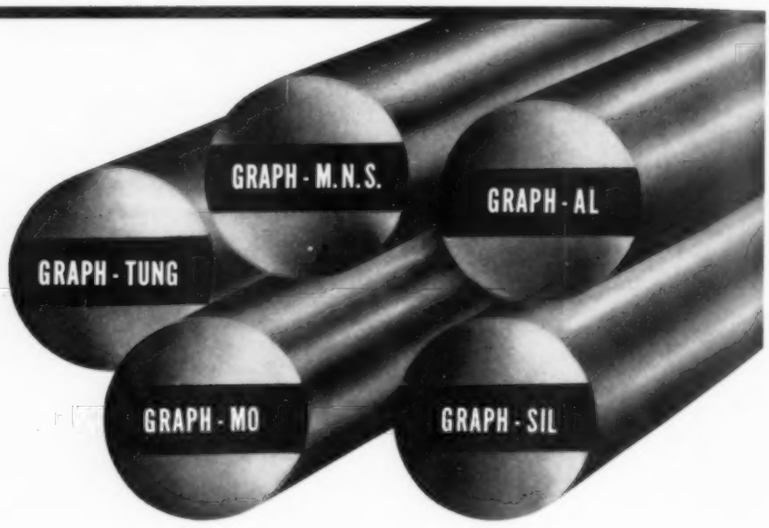
ARISTOLOY STEELS

COPPERWELD STEEL COMPANY WARREN, OHIO

Two ways to speed up Defense Production . . .



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You no doubt have thought of this method before. We hope you have been successful.

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Perhaps you're using them now. We hope you are. They machine 25% faster than comparable steels and wear longer.

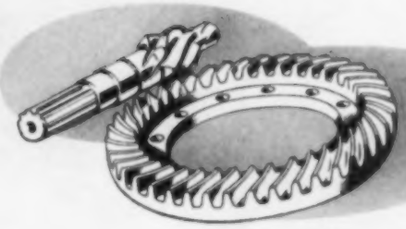
Write today for the newly revised and enlarged 5th Printing of the Graphitic Steel Booklet.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
Steel and Tube Division

TIMKEN
ALLOY STEELS

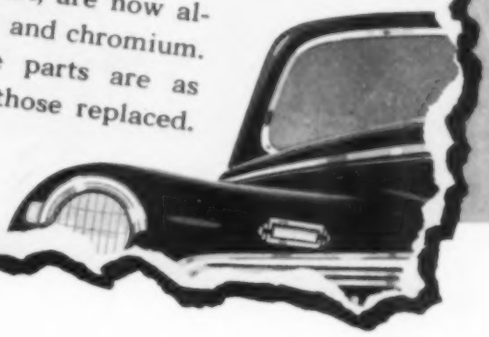
Manufacturers of TIMKEN Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; TIMKEN Alloy Steels and Carbon and Alloy Seamless Tubing; and TIMKEN Rock Bits.

Ford turns to MOLYBDENUM



Molybdenum Replaces Nickel

Nickel is important not only in the finish of plated metal but in improving the toughness of steel. In defense production it is used in the manufacture of aviation engine parts and armor plate. Ford valves, transmission gears, shafts, and other parts formerly containing nickel, are now alloyed with molybdenum and chromium. For the purpose, these parts are as good as or better than those replaced.



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Mines: Tucson, Arizona; Questa, New Mexico.

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Offices and Warehouses: Pittsburgh, New York, Chicago, Detroit, Los Angeles, San Francisco, Seattle, Montreal.

Sales facilities, technical advice, ample stocks available.

The advertisement of the Ford Motor Company here reproduced in part, is appearing in current magazines of general circulation. It gives an instance of the manner in which Molybdenum is entering into defense.

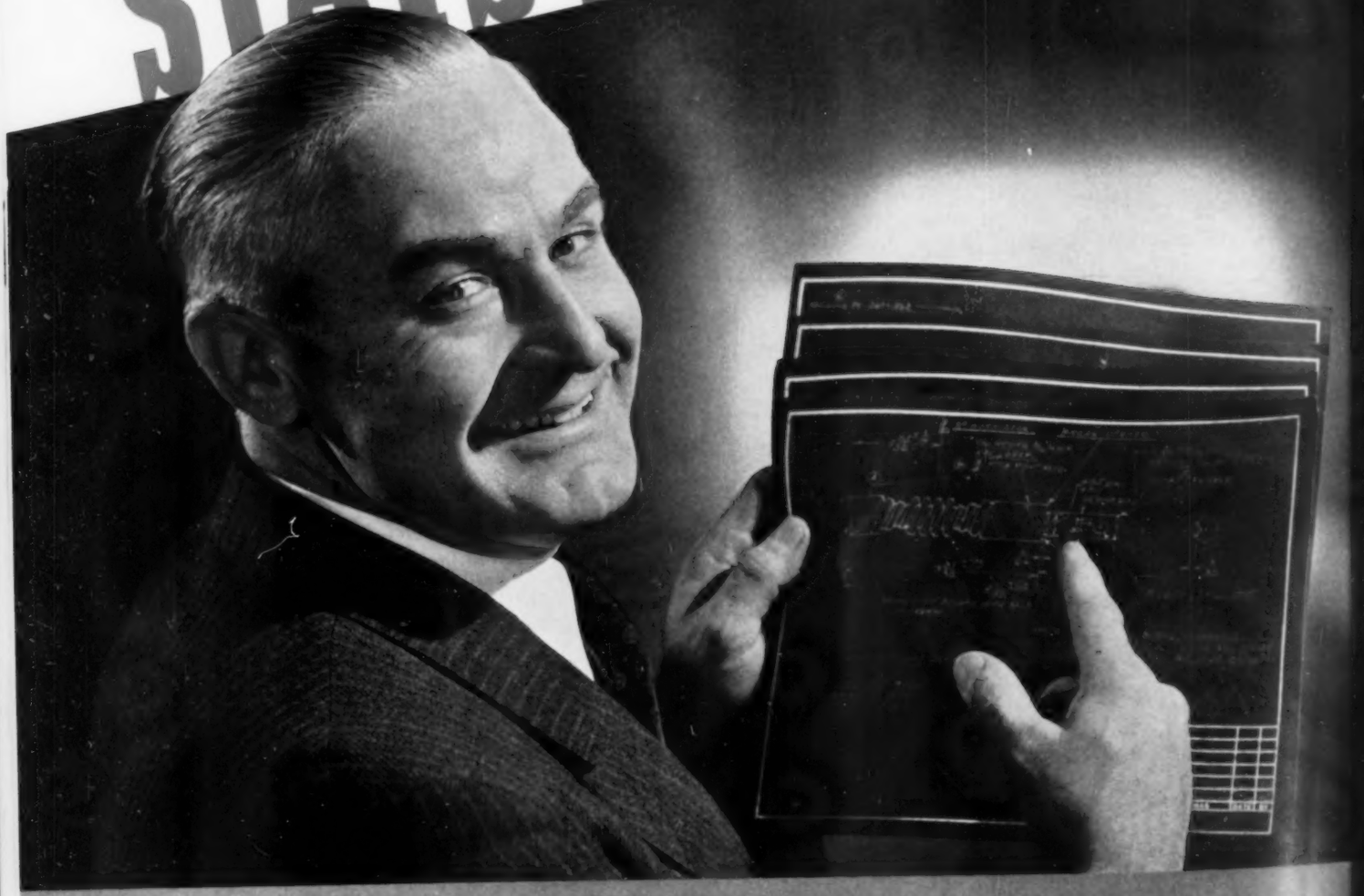
The Molybdenum Corporation of America, with adequate sources, supplies, and facilities under one management, invites your orders or your requests for information.

MOLYBDENUM CORPORATION OF AMERICA

GRANT BUILDING, PITTSBURGH, PA.

MCA

"Practical
ENGINEERING SERVICE
Is One of the Reasons La Salle
STAYS AT THE TOP



La Salle STEEL COMPANY
Manufacturers of the Most Complete Line of Cold Finished Steel Bars in America

OF OUR LIST"

FOR COLD FINISHED STEEL BARS

● The great production demands now being made on plants and shops make "practical engineering service" on cold finished steel bars extremely valuable. Such service, as developed and practiced by La Salle for many years, has meant many things:

It has meant going into a plant and helping the buyer determine the one right steel for every job.

It has meant working understandingly with machine tool operators to get more production out of present equipment.

It has meant going into a huddle over parts blue-prints to weed out obsolete steel bar grades and to recommend newer, more efficient analyses.

It has meant briefly, making available all the accumulated background and experience of years of working with cold finished steel bar users.

Such "practical engineering service" now is paying dividends in hundreds of plants where La Salle recommendations are helping management meet defense-quickened schedules. It is one of the many reasons why La Salle today stands high on purchasing agents' lists of suppliers. It explains one of the reasons why La Salle will *stay* at the top of the list for hundreds of cold finished steel bar users for years to come.

LA SALLE STEEL COMPANY · CHICAGO, ILLINOIS

★ ★ ★ ★ ★ ★ ★ ★ ★

As with the rest of the industry, La Salle's No. 1 job now is co-operating to the fullest possible extent in the Defense Program.

★ ★ ★ ★ ★ ★ ★ ★ ★

★ *Engineered Quality*
★ *Advanced Research*
★ *Practical Metallurgy*

La Salle STEEL

IN THE MIDWEST
IT'S *La Salle*

Reduction in Traffic Delay Through

CENTRAL LOCATION

An important factor in La Salle's acceptance as the "top" source of supply by many steel bar users is its central location. The La Salle plant at Hammond, Indiana is directly served by three railroads and a main trunk highway. This reduces to a minimum the possibilities of delay in shipments due to inadequate transportation facilities.

Time and Money Saved by

"MOST COMPLETE LINE"

The economy, convenience and safety of having a source that is equipped to give service on a *complete* line of products rather than on only a portion of a users's requirements is seldom overlooked by buyers of cold finished steel bars. La Salle produces "The Most Complete Line of Cold Finished Steel Bars in America."

Faster Production, Lower Costs Through

ADVANCED RESEARCH

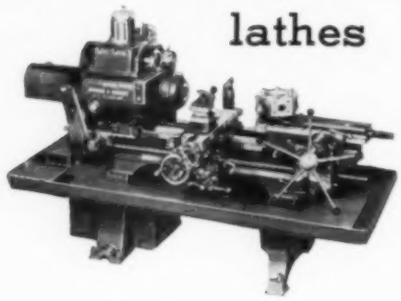
Faster cutting, better, lower cost materials for steel users is the purpose of La Salle's research which never stops. Experienced metallurgists are unceasingly searching for new improved steels to add to those developed in the past: 1020-90, Silver Tip, Gold Tip, Tritex, Tuftork and STRESSPROOF. Another factor which makes La Salle "stay at the top of the list"!

Cash in on La Salle's

FORESIGHT

"Yesterday's Foresight Meets Today's Demands" is the basic policy of La Salle's continuous effort to serve users better and better. Expanded facilities, improved methods of operation and better and better steels are the result—results that pay dividends to users who think of La Salle as their main source of supply for cold finished steel bars.

Behind famous **Warner & Swasey** turret lathes



. . . speedy, dependable GAS

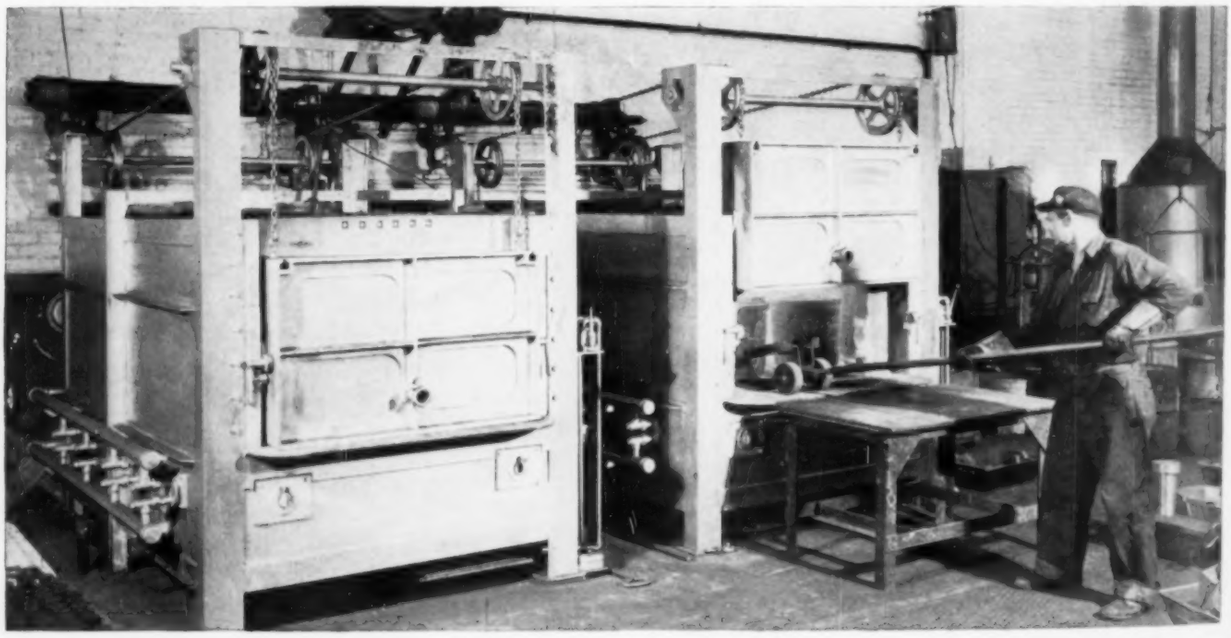
The pressing need for machine tools has been uppermost ever since Defense created the first industrial bottleneck. Throughout American cities, are alert, ingenious firms with the ability to produce machine tools of all kinds. Among them is The Warner & Swasey Company of Cleveland, noted for versatility in production of fine machine tools.

In The Warner & Swasey's plant are two large Gas furnaces used to heat treat a great variety of steel parts for turret lathes. They are used for annealing and carburizing bushings, lock-bolts and other steel parts. Each of the furnaces, capacity 43,200 cubic inches, operates night and day.

The use of Gas for heat treating steel parts in this intricate and exacting machine tool field is proof of the admitted value of Gas in all metallurgy. The fact is that Gas is today behind thousands of Defense contracts with A-1, A-2 and other high priorities ratings.

There are plenty of good reasons for this. Gas is fast, clean, accurately controllable—well worth investigating if you have a production problem in your plant. Ask your Gas company for recommendations.

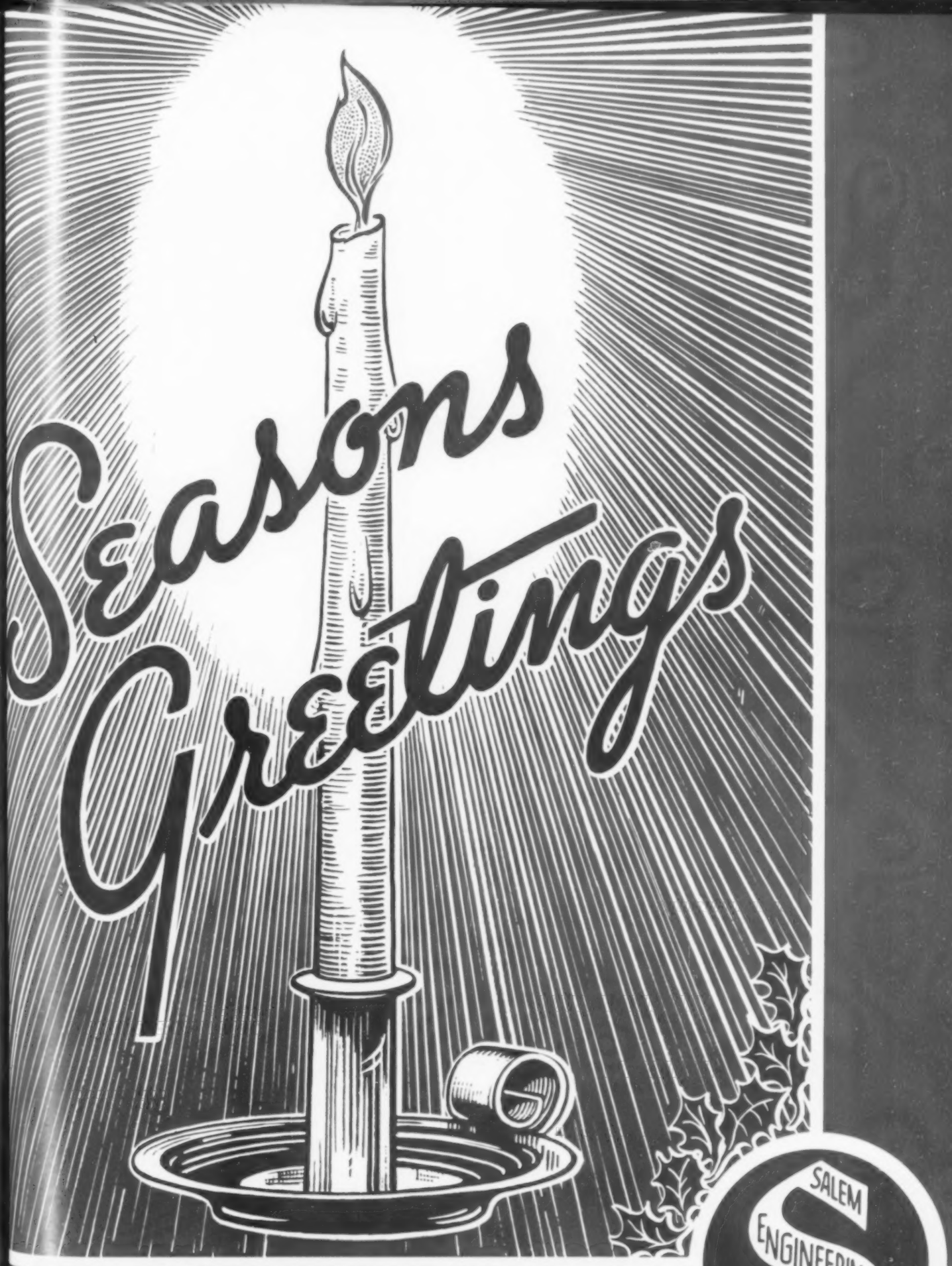
AMERICAN GAS ASSOCIATION
INDUSTRIAL and COMMERCIAL GAS SECTION
420 LEXINGTON AVE., NEW YORK



Top: One of the famous Warner & Swasey turret lathes, which have been in the headlines ever since Defense and OPM began to get under way.

THE TREND IS TO GAS
FOR ALL INDUSTRIAL HEATING

Two Gas-fired "conjecto" type Surface Combustion furnaces for heat treating turret lathe parts, The Warner & Swasey Co., Cleveland, Ohio

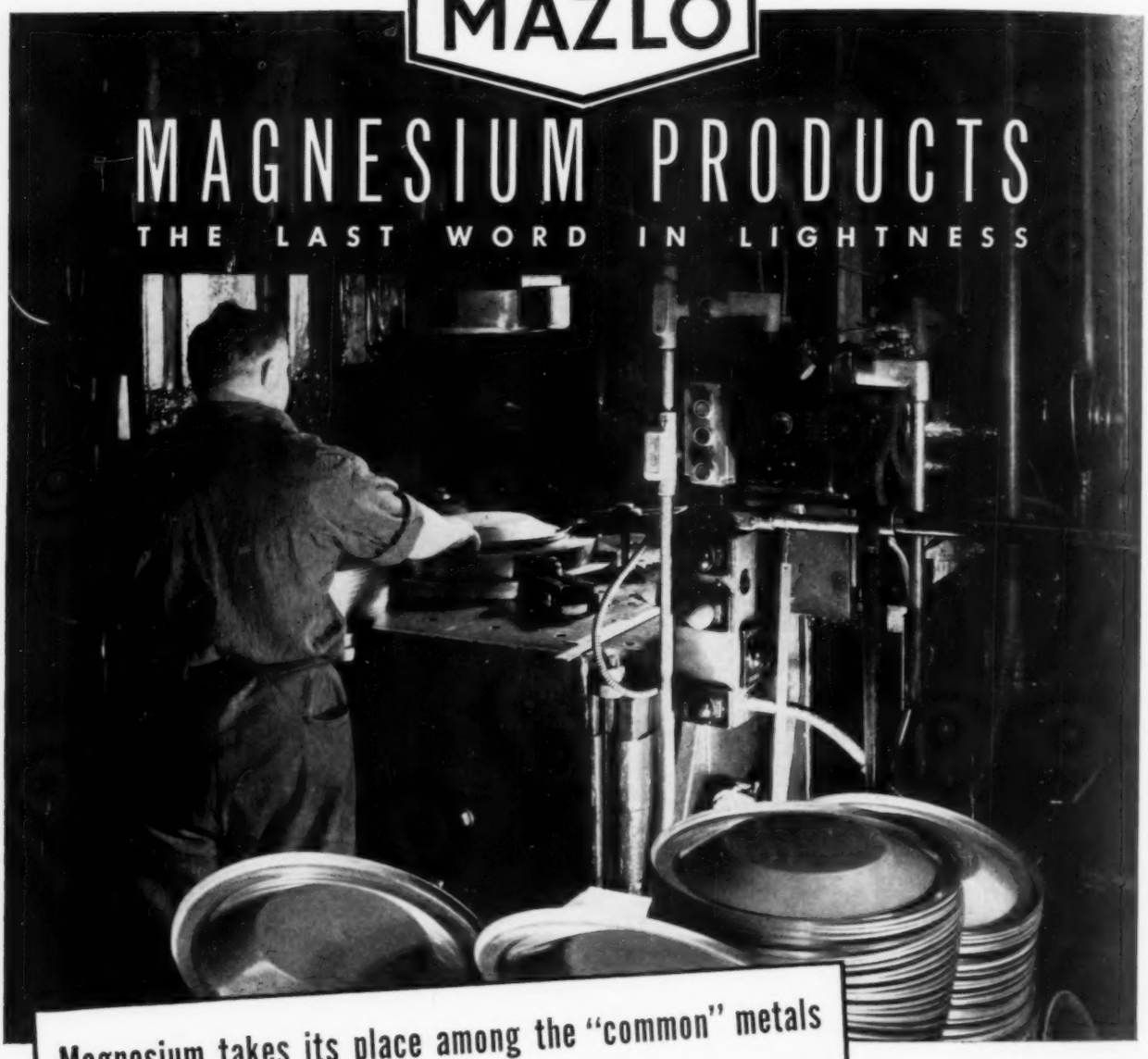


SALEM
ENGINEERING
COMPANY

MAZLO

MAGNESIUM PRODUCTS

THE LAST WORD IN LIGHTNESS



Magnesium takes its place among the "common" metals

MAZLO factories are doing today what they've dreamed of doing for years. They're in mass production on many Magnesium Alloy products, fabricating and helping other manufacturers produce in tremendous quantities.

What fabricators are learning in this push for production will later profit every peacetime user of Mazlo Magnesium products. Improved manufacturing methods and reduced costs will increase the usefulness of Magnesium in every commercial form. Many new applications are indicated.

Magnesium has earned wide acceptance because of the unusual advantages it offers. As metal again becomes generally available for non-defense uses, consumers and manufacturers alike will be able to profit fully by using this lightest of lightweight metals in an ever widening circle of applications.

MAZLO

REG. U.S. PAT. OFF.

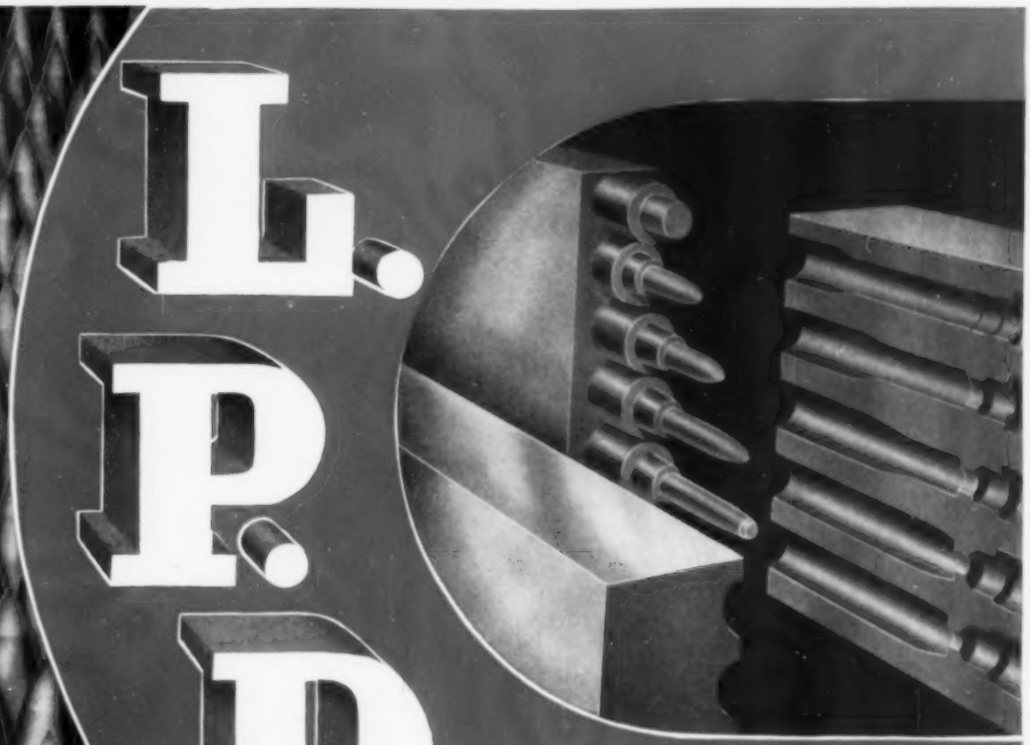
DEFENSE COMES FIRST

Magnesium, today, is "All Out for Defense." Civilian users have had to find substitutes. But we have not turned our backs. American Magnesium Corporation is increasing its fabricating facilities at a rate many times that required by normal peacetime markets. When the emergency is past, there will be an abundance of these lightweight products for all users. Sales Agent for Mazlo Magnesium products: Aluminum Company of America, 1706 Gulf Building, Pittsburgh, Pa.

AMERICAN MAGNESIUM CORPORATION

Subsidiary of Aluminum Company of America

LATROBE



L. P. D.

A HOT WORK DIE STEEL

The tempo of today's defense preparations is greatly accelerated by the modern methods employed in shell manufacture. LATROBE is doing its part by making available L. P. D., an ideal hot-work steel for shell punches and dies. L. P. D. offers excellent resistance to wear at high temperatures, and affords maximum precision in the many operations requiring hot forming dies. *Write for your copy of our special bulletin on L. P. D.*

LESCO

Latrobe ELECTRIC STEEL COMPANY

MAIN OFFICES *and* PLANT · · LATROBE · PENNSYLVANIA

. . . AND THEN THEY CALLED IN

THE MAN FROM CARNEGIE - ILLINOIS

A bedspring manufacturer faces the job of producing machine gun clips. A staybolt maker converts his entire production to machine gun barrels. Armor piercing bullets in an endless stream are produced by a gear maker. Heavy caliber shells roll swiftly from a factory that formerly made linoleum rugs.

PICTURE what's been happening to the men in these plants. For them, this swing-over from peacetime manufacture to production for defense, has been one long succession of headaches. In most cases they have had to start from scratch to learn how to turn out, in huge quantities and quickly, a product entirely new and unfamiliar. Often they have had to master equally unfamiliar processes of manufacture.

Even when the tough problems of equipment and personnel had been solved, other questions just as important still remained to plague them: What steel to use? How to get the high physicals demanded? How to meet the exacting standards required? . . . It was then they wisely called in the man from Carnegie-Illinois.

In one plant after another, our steel metallurgists have been able to lend a helping hand. Drawing on their wide experience in the latest fabricating techniques, they have shown how to speed up forging, to save time in welding, to reduce machining schedules. Again and again their suggestions have lead to important modifications in manufacturing methods that have worked wonders in obtaining highly desirable physical properties formerly thought impossible.

This practical advice and cooperation are available to every user of Carnegie-Illinois steel and to every manufacturer of defense materials.

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* — United States Steel Export Company, New York

UNITED STATES STEEL

USS

Thanks a Million..

★ THIS year more people have come to us for more steel than ever before in our long history.

★ Such confidence is highly appreciated and we hope that we have proved worthy of it.

★ There have been many changes which affected us all, but our friends have demonstrated their cooperation in ways that stimulate our desire to be of greatest possible further service.

COLUMBIA TOOL STEEL COMPANY

Arthur T. Clarage, PRESIDENT

Columbia Tool Steels

It pays to use Good Tool Steel.

★ MAIN OFFICE AND WORKS, CHICAGO HEIGHTS, ILL.

ANNOUNCING THE NEW Thermonic "2700"

The First High Frequency Electronic Generator in the Field

2700 Is a Power-Packed Thermonic Generator of 50 K.W. Output (2700 B.T.U. per minute).

2700 Is the lowest operating cost high frequency generator available.

2700 Opens new fields of application of high frequency current in the metal field as well as dielectric field.

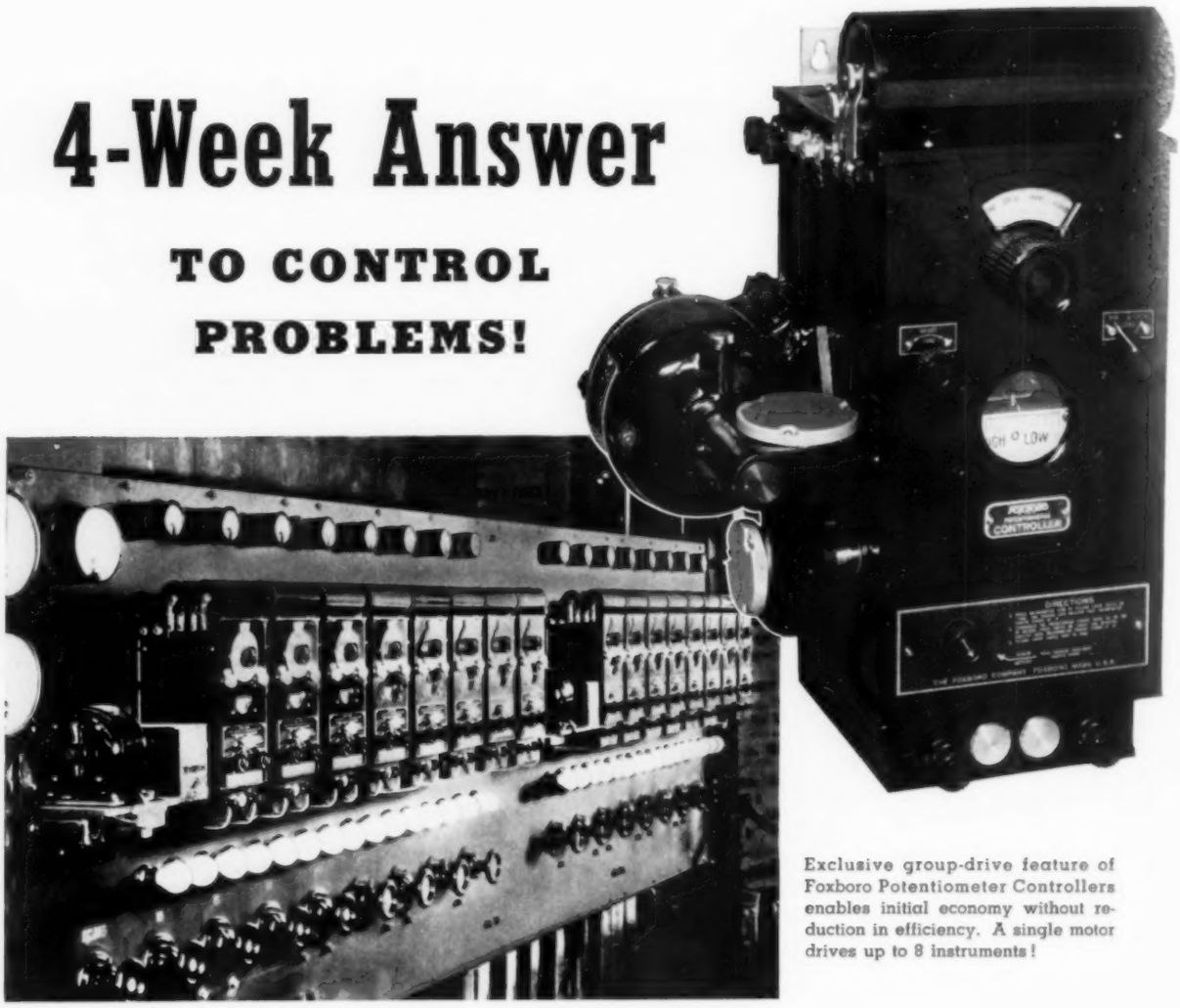
2700 Has no moving or rotating parts. The output section is portable and can be moved about. Its actual area is 33" x 37" x 5' 6". The other units can be placed anywhere and remotely connected.

—AND A PROMISE OF GREATER THINGS TO COME

INDUCTION HEATING CORPORATION, 389 Lafayette St., N.Y.

4-Week Answer

TO CONTROL PROBLEMS!



Exclusive group-drive feature of Foxboro Potentiometer Controllers enables initial economy without reduction in efficiency. A single motor drives up to 8 instruments!

Dependable Heat-Control available FAST through Foxboro Potentiometer Controllers!

When tough heat-treating specifications on defense orders "put you on the spot" for precision automatic control . . . non-recording, two-position Foxboro Potentiometer Controllers can pull you out of it *fast*. They're available for delivery within three to four weeks, without any compromise in quality!

These trouble-free pyrometers are earning an outstanding reputation for dependability. Many industries now regularly re-order them *by preference*, after comparing results of original installations. Every detail of construction is designed for utmost simplicity . . . to make precision operation easy . . . to eliminate wear and maintenance troubles . . . to insure *sustained* control-accuracy!

For example, the Foxboro fixed slide-wire contact makes possible exact, knife-edge detection and the use of large trouble-proof parts. Another advance is the extra-large setting-dial that makes precision setting as easy as tuning a radio!

Get the full story on Foxboro Potentiometer Controllers . . . the precision pyrometers that can be obtained promptly. Write for Bulletin 202-3. **The Foxboro Company, 52 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities of United States and Canada.

FOXBORO

Reg. U. S. Pat. Off.

Potentiometer Controllers

What Zirconium Does for High-Chromium Steels . . .

THE ADDITION of zirconium to high-chromium steel castings makes them clean, free from porosity, and strong. For instance, 0.22 per cent zirconium was added as 35 to 40 per cent zirconium alloy to a 12 to 14 per cent chromium steel in the furnace just prior to tapping, and this steel had exceptional cleanliness, a satisfactory microstructure, and good physical properties. After heating at 1,825 degrees Fahrenheit for one hour and air-quenching, and then heating at 1,400 degrees Fahrenheit for two hours and air-cooling, its properties were:

Yield Point	57,500 lb. per sq. in.
Ultimate Strength	87,250 lb. per sq. in.
Elongation	23.0 per cent
Reduction of Area	37.3 per cent

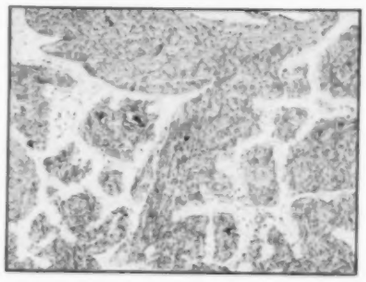
One of our metallurgists will gladly call at your request and explain further the benefits of zirconium in steel. He can tell you also about the many other "Electromet" quality ferro-alloys for improving steel and sometimes increasing the speed with which it can be made. Furthermore, he can give you practical help in using these alloys for greatest economy and best results. Write for this service today, without obligation.

ELECTRO METALLURGICAL COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York, N. Y.

Small, well-distributed inclusions in a 12 to 14 per cent chromium steel casting treated with 0.22 per cent zirconium added in the furnace as 35 to 40 per cent zirconium alloy. Unetched specimen magnified 100 diameters.



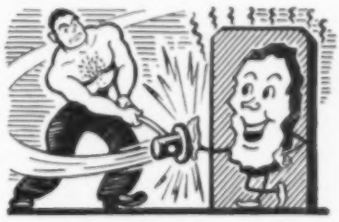
Microstructure of the same steel. The structure is fine-grained, sound, uniform, and clean. The few inclusions are not harmful. Specimen etched with aqua regia and glycerine, and magnified 100 diameters.

Items of Interest about other "Electromet" Ferro-Alloys

•

High-Nitrogen Ferrochrome Improves High-Chromium Steel Castings—High-nitrogen ferrochrome adds both nitrogen and chromium to steel. A small per cent of nitrogen in cast steels containing over 20 per cent chromium greatly refines grain size, inhibits objectionable grain growth at high temperatures, materially increases strength and toughness and effects a slight increase in hardness.

Columbium Increases Usefulness of 4 to 6 Per Cent Chromium Steels—The addition of about 0.50 per cent columbium to the



wrought 4 to 6 per cent chromium steels greatly reduces air-hardening, gives higher impact strength regardless of heat-treatment or temperature, improves oxidation resistance, increases creep strength, and improves weldability. Therefore, columbium-bearing 4 to 6 per cent chromium steels have a greatly widened field of usefulness.

• • •

If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

Electromet
Trade-Mark
Ferro-Alloys & Metals

Available through offices of Electro Metallurgical Sales Corporation in Birmingham, Chicago, Cleveland, Detroit, New York, Pittsburgh, and San Francisco. In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

PRODUCTS OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

The word "Electromet" is a registered trade-mark of Electro Metallurgical Company.

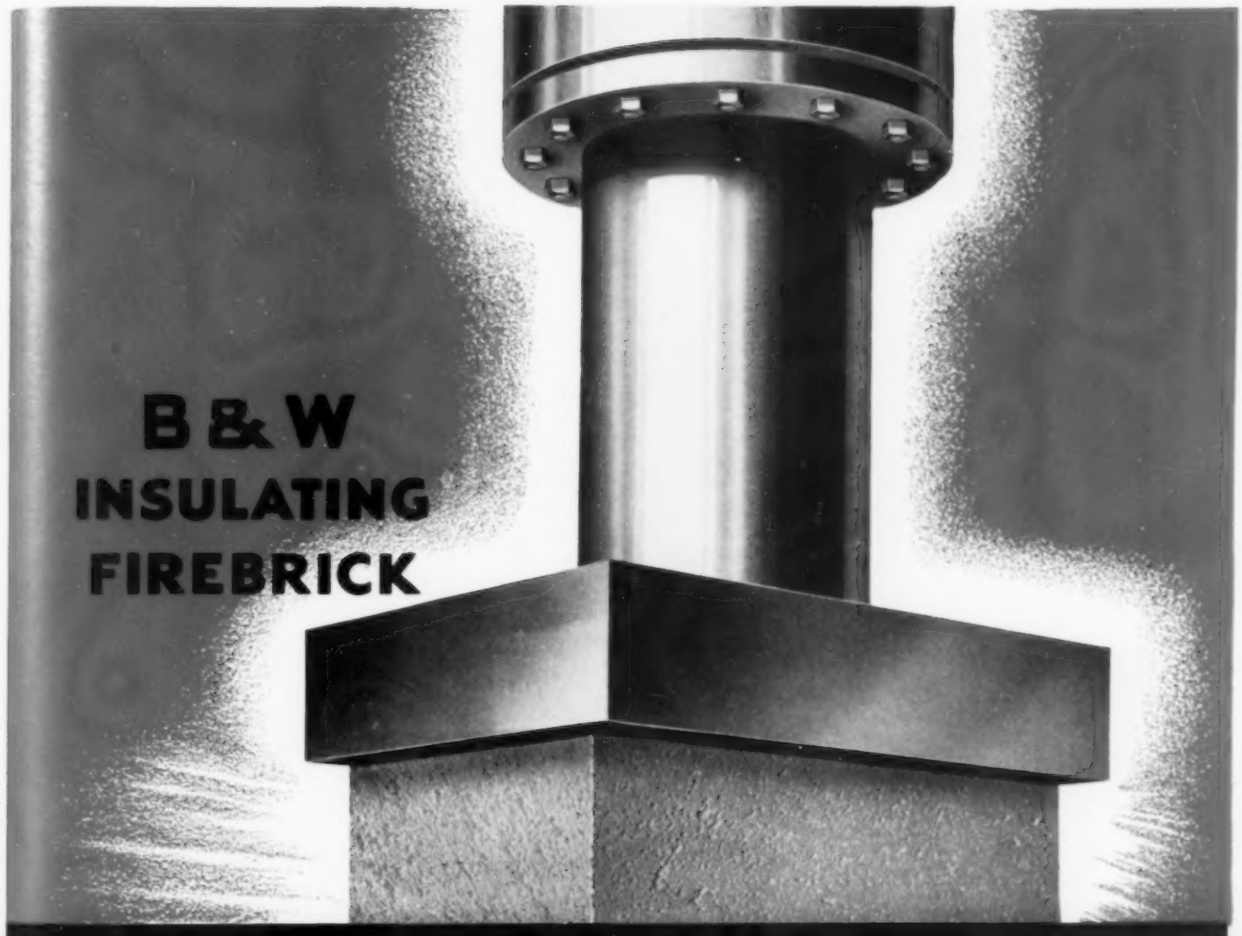
WHITEY SEZ: *"A FEW ROLLING PRIORITIES WELL DIRECTED MIGHT BETTER THE DELIVERY OF MAURATH STAINLESS ELECTRODES, BUT THE QUALITY OF THE ROD ADVANCES ONLY WITH THE ADVENT OF BETTER STEELS AND ANY PERFECTION WE MIGHT PERSONALLY SEE FIT TO IMPROVE THE COATING."*

STAINLESS
Type Numbers Available

302-B	316	330
308	316-Cb.	347
309	317	410
309-Cb.	321	430
310	325	442
311	329	446
312	•	502

15% Cr.—65% Ni.
20% Cr.—80% Ni.

MAURATH, Inc. **CLEVELAND**
Builder of better welding electrodes in all analyses



RESERVE STRENGTH
...at service temperatures

The high hot-load strength of B&W Insulating Firebrick gives them a substantial margin of extra or reserve strength to withstand present day furnace-operating conditions. This is quite different from the cold-crushing strength that is determined by a laboratory test. It is the kind of strength that means stability and long life when insulating firebrick are used in a furnace of which maximum production is demanded.

THE BABCOCK & WILCOX COMPANY
Refractories Division, 85 Liberty St., New York, N. Y.

BABCOCK & WILCOX

R-136

"Hay!" We are not this slow!

Our expanded facilities and efficient organization offer you . . . . . .

Remarkably fast deliveries on North American Burners, Mixers, Regulators, Valves and Accessories.

If you are looking for dependable Combustion Equipment in a hurry, we invite you to try

Combustion Equipment by

NORTH AMERICAN

THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

CLEVELAND, OHIO

BRANCH OFFICES WITH FACTORY TRAINED REPRESENTATIVES IN PRINCIPAL CITIES

Advertisement DECEMBER, 1941

COPPER ALLOY BULLETIN

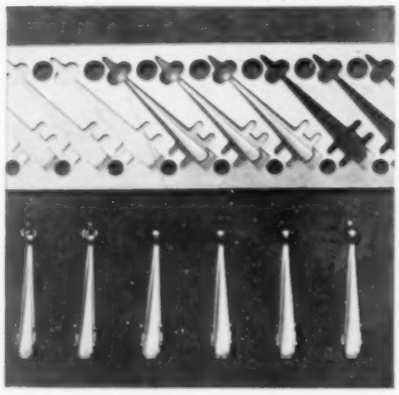
REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Die-Stamped Parts Readily Produced From Brass Sheet

Small parts of accurate dimensions, such as clips for pens, pencils, and pocket thermometers, can be economically die-stamped from brass sheet of controlled quality. The accompanying illustration indicates how easily clips can be formed from Bridgeport brass sheet by multiple die-stamping operations. As the brass sheet is fed into the press, the trade name is stamped on the metal, the contour of the part is shaped, and the clip is punched out in rough finished form. Because of the clean cutting character of Bridgeport brass sheet, the rough stamped parts require no intermediate finishing. They are fed directly into a press designed to shape and "ball" the clip end in a single operation.

Courtesy of Marshall & Meier



Duronze* III Resists Attack by Fuel Oils

Exceptionally high corrosion resistance of Duronze III is demonstrated by its successful performance in the screw machine part illustrated, which is used in assembly of aircraft carburetors. In addition to withstanding the severe corrosive attack of hot gasoline in this application, Duronze III has the further advantages of very high strength, smooth, hard surface, and light weight.

Duronze III also displays high resistance to the action of the elements, sea water, dilute acids, and many other chemicals.

Proper Control of Annealing Is Essential in Brass Fabrication

Operation is One of the Most Important in its Effect on Strength, Ductility, and Other Characteristics of Brass

One of the reasons why brass is so useful is that the physical properties of a given alloy can be varied over a wide range, depending upon whether it has been finished by annealing or cold working, and further depending upon the severity of these operations.

In order that the properties of a batch be sufficiently uniform for the processes to which it is to be subjected, it is important that these operations be carefully controlled.

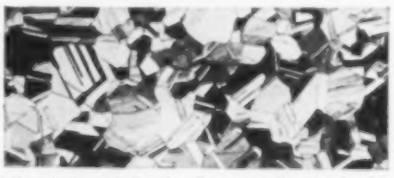
Too much emphasis cannot be placed upon the importance of the annealing or heat treating operation as applied to the brasses. Unlike steel, brass in its soft or annealed condition is a metal of moderate strength and excellent ductility. However, upon cold working, such as rolling or drawing, brass becomes stiff and hard, its tensile strength rising rapidly with decreasing ductility. Cold worked material can be made soft and ductile again, however, by annealing or raising the metal to a red heat. In other words, the nature and physical properties of brass depend mainly upon the final treatment which it receives: namely, annealing (softening) or cold working (hardening).

Relief Annealing

Since hardness and strength in brass are artificially induced by cold working, it often happens that finished articles made by forming, drawing or stamping contain serious stresses which may let go under certain conditions causing cracks or breaks in the material. Such stresses can generally be eliminated by relief annealing at a temperature too low for recrystallization or softening. Relief annealing is used in many cases where articles are to be kept in storage for long periods of time.

True annealing takes place when the material is heated at a sufficiently high temperature so that recrystallization actually takes place. In general, this change in structure is accompanied by softening. With rising temperatures of anneal, the crystals grow larger, with corresponding increased ductility and lower tensile strength.

Under the microscope the brass shows a crystalline structure—the size of the crystals increasing with rising temperature. By controlling the grain size, brass of various degrees of softness can be made. The coarse-grained material presents a rough surface after stretching resulting from forming or cupping. If it is necessary to polish or buff such a surface, considerable cutting down must take place, accompanied by higher finishing costs. A fine-grained material requires much less polishing and results in a better finish. A medium-sized structure is desirable for ordinary drawing operations.



(Above) Annealed yellow brass, medium grain size, Mag. 75X. Tensile strength about 45,000 pounds per square inch.

(Above) Cold worked yellow brass, Mag. 75X. Tensile strength about 62,000 pounds per square inch.

Types of Equipment

Although the type of furnace and nature of the fuel are important from an operating standpoint, nevertheless almost any annealing equipment will produce the desired results if careful attention is given to good annealing practice. Best results are obtained with a furnace large enough so that the batch of metal to be annealed can be brought up close to the indicated furnace temperature. In cases where the annealing equipment is too small, the common practice is to rush the annealing by maintaining the furnace considerably higher than the desired annealing temperature and pulling the material out of the furnace before it attains furnace temperature. Such practice is dangerous because of the uncertain time element—a little longer period in the furnace may bring the metal up to a higher temperature than required, while a shorter period may result in only part of the material attaining the annealing temperature. In other words, non-uniformity results from lack of annealing facilities.

Certain brass alloys, especially those which contain copper above 85%, oxidize rapidly when exposed to the air when in a

(Continued on page 2, column 2)

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

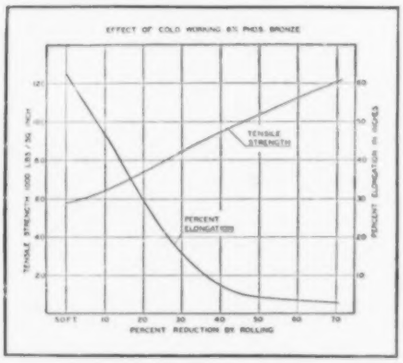
This is the twenty-ninth of a series of articles on the properties and uses of the copper alloys, and continues the subject of the copper-tin alloys.

PROPERTIES OF COPPER-TIN ALLOYS

The properties of the copper-tin alloys which have made them particularly useful are their combination of good fatigue life, corrosion resistance and spring characteristics. The last item is difficult to define exactly but seems to be related to high elastic limit and resistance to creep at room temperature. This combination of properties is responsible for the use of phosphor bronze clips in almost all types of electrical switch contacts. In order to secure these mechanical properties it is necessary to furnish the strip or wire in the cold worked condition.

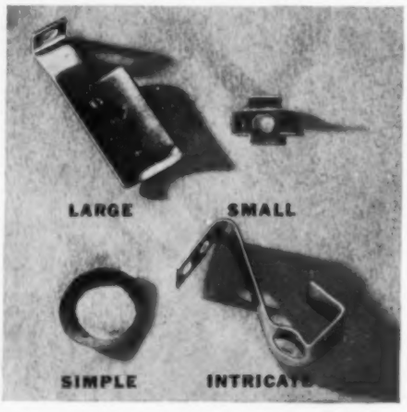
Because of their cost the alloys have only been used when cheaper alloys could not be used. This is unfortunate for the alloys have other properties which are highly desirable. In the annealed condition the 8% tin alloy has an excellent combination of ductility and strength, being actually superior to cartridge brass in those respects. These properties lead to the use of phosphor bronze in some of the highest quality thermostatic bellows, where ability to withstand severe stretching operations combined with good tensile strength and elastic properties are important.

It is apparent from the accompanying curves that the alloy has many attractive properties which have not been fully exploited because of the cost of the material. These curves cover the mechanical properties of the 8% tin phosphor bronze as affected by cold working and annealing.



Phosphor Bronze Is Readily Fabricated

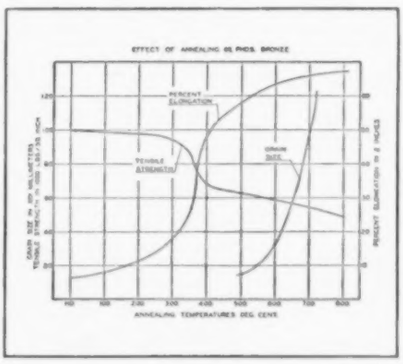
The ease with which Bridgeport New Phosphor Bronze is adaptable to the fabrication of many types of parts—large or small, simple, or intricate—is indicated by the accompanying photograph of typical phosphor bronze items. Bridgeport's carefully controlled methods of processing assure a phosphor bronze with the qualities that contribute to ease of fabrication as well as to long life and lasting resilience.



Annealing of Brass

(*Continued from page 1, column 3*)

red hot condition. Oxidation can be prevented by using non-oxidizing furnace equipment. Where this is not available the oxidized surface can be removed by pickling in a dilute sulphuric acid pickle. The best practice, of course, is to prevent oxidation in the first place.



NEW DEVELOPMENTS

An automatic thread-milling machine is said to be designed to produce internal and external threads of a high degree of accuracy at rapid speeds. Manufacturer says that the operator need only load and unload the machine and actuate the starting lever, all other machine functions being performed automatically. **(No. 270)**

A shell-spraying machine is provided with an electric eye control that shuts off the spray when there is no shell in the work holder, it is reported. Machine coats exterior and interior surfaces in one operation. **(No. 271)**

A pneumatic comparator gage is reported to amplify small dimensions accurately and show them on a dial type indicator. According to the maker, the gage is especially suitable for production work, because the "wear" factor is eliminated. The measuring points are actually air nozzles, which do not touch the piece being gaged, and are therefore not subject to wear. **(No. 272)**

A new precision machine is reported to be especially adapted to accurate milling, boring, facing, and routing operations in tool, die, and machine shops. V-belt drive provides a wide range of speeds. Suggested applications include the manufacture of small parts for instruments and munitions. **(No. 273)**

A pickling agent recently placed on the market is said to have exceptional advantages in the processing of copper and copper alloys. Maker says that it can be used successfully on brasses, including leaded brass, silicon bronze, phosphor bronze, and many other copper alloys, as well as on pure copper. Among the reported advantages of the new material are rapid and thorough pickling, prevention of red stains, improved surface appearance, and reduction in the danger of attacking the metal. **(No. 274)**

A sensitizing process for copper and brass is said to permit the making of templates by photographing drawings directly on the metal surface, thus eliminating considerable hand layout time. The process, which involves coating the metal with a photographic emulsion, can be applied also to the making of nameplates, instrument dials, and similar parts, it is claimed. **(No. 275)**

A new hardness tester is provided with an attachment that simplifies testing on irregular surfaces not easy to reach with conventional instruments. Tester is of the small portable type, and is said to be adapted to both metals and finishes. **(No. 276)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS—*Brass, bronze, copper, Duronze**, for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES—For steam surface condensers, heat exchangers, oil refineries, and process industries.

*Trade-name.

PHONO-ELECTRIC* ALLOYS—High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

"Bridgeport" BRASS CO.

Established 1865

COPPER WATER TUBE — For plumbing, heating, underground piping.

DURONZE ALLOYS — High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

BRASS, BRONZE, DURONZE WIRE— For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT. —Engineering staff, special equipment for making parts or complete items.

BRASS AND COPPER PIPE—"Plumrite"* for plumbing, underground and industrial services.

BRIDGEPORT BRASS

Out of Today's Emergency—

BETTER REPUBLIC STEELS FOR TOMORROW!

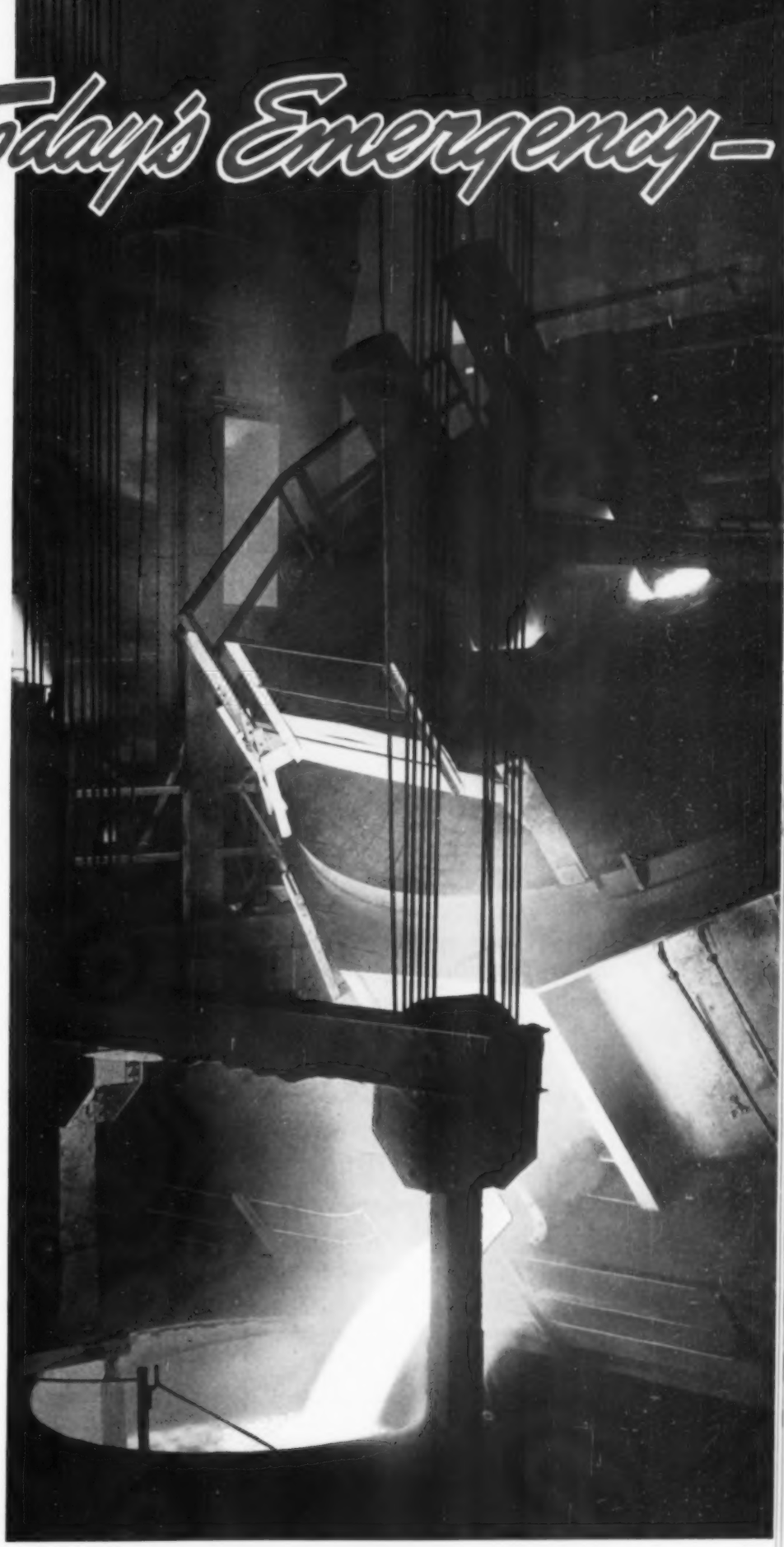
Bombers must fly higher and farther—pursuit planes faster. Guns must withstand more rapid fire. Tanks must be more dependable in swift maneuver—battleships better protected.

Demands like these call for the finest steels ever produced—for new steels, improved steels — in tremendous quantities.

Anticipating this need, Republic—already the world's largest producer of alloy and stainless steels — has jumped its electric furnace capacity in the last two years from *146,000 to 720,000 tons a year.* Right now, Republic is increasing its plate capacity to 600,000 tons a year—a rise of 58%. Annual pig iron capacity will be increased 36%—to 6,620,000 tons. A new armor plate plant already is in active production. And Republic research, famous for its achievements, has been greatly intensified.

When a peace-time tomorrow arrives, the steels which enable us to build faster warplanes, stronger tanks, guns and battleships will mean safer, swifter transport and private airplanes—finer automobiles, trucks, railroad trains and machinery — even better washing machines, refrigerators, stoves and thousands of other products in which steel makes life more livable, more comfortable, more enjoyable.

And when that tomorrow comes, Republic will be ready to produce these steels in quantities sufficient for everyone.



REPUBLIC STEEL CORPORATION

General Offices: Cleveland, Ohio

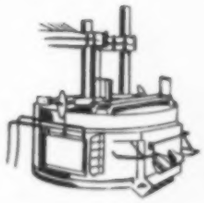
Berger Manufacturing Division
Culvert Division
Niles Steel Products Division
Steel and Tubes Division
Union Drawn Steel Division
Truscon Steel Company

REPUBLIC STEEL — DEFENSE FOR AMERICA

Anticipating the growing need for electric furnace steels, Republic has increased its electric furnace capacity approximately 500% in the last two years.

IN 1939
146,000 TONS ANNUAL CAPACITY

IN 1941
720,000 TONS ANNUAL CAPACITY



Current notes on BETHLEHEM ALLOY STEELS

GEAR STEELS

The airplane, the automobile and practically every other type of mechanism, light or heavy, employs a number of gears. To meet the varied needs of a host of manufacturers, a number of alloy steels have been developed which may be grouped in the general classification of gear steels. Thus, the current exacting demands of ultra-heavy-duty military trucks, tanks and gun carriages find the engineer and designer already equipped with special steels suited to these and other defense applications.

Since hardness and toughness are both essential in gears, a number of alloy steels of carburizing grades are commonly used, as well as those of oil-hardening grades. These latter differ from carburizing grades in having higher carbon content—ranging, in the case of oil-hardening gear steels, from 0.45 to 0.60 per cent carbon. Gear steels of both grades include numbers of alloy steels containing nickel, chromium, molybdenum and vanadium in various combinations. Because of shortages of some of these alloying elements—notably nickel and chromium—a number of alloy gear steels are available only for direct defense applications. In non-defense applications, the designer's choice is limited to other steels, a number of which have been developed to meet this requirement.

The special care taken in production to insure cleanness in gear steels is a factor making for good machinability, but this quality depends also on correct annealing of forgings. Since minimum distortion in treatment is of great importance in production work on gears, extra care must be taken in heat-treating. In all cases, the recommended annealing and heat-treating practice for each specific steel should be followed closely.

BETHLEHEM STEEL COMPANY

BETHLEHEM STEEL

Houghton's QUENCHING OIL developed solely for HIGH SPEED QUENCHING OF SHELLS

History repeats itself. In the first World War Houghton helped establish a procedure for heat treating shell steel. Again the problem arises, as shortage of types of steel for projectile use, combined with higher yield strength requirements, make it necessary to quench high explosive shells.

The quench is the crucial part of the heat treat. It must be uniform. It must be rapid in cooling through the critical range. The oil must not sludge or clog up cooling systems. It must not oxidize nor fractionally distill.

These are the requirements—a speedy, uniform quench, yet not so fast as to cause any tendency to crack or distort.

HOUGHTO-QUENCH G has been developed to fill this need. Its merits are set forth on this page. It is made solely for quenching; by dilatometer test it has definitely faster quenching speed. It is an exclusively treated oil, superior on all counts to other quenching oils against which it has been tested for speed, depth of hardness and stability. Yet it is priced right to provide an economical installation.

WHY HOUGHTO-QUENCH "G" EXCELS:

1. Possesses faster quenching speed.
2. Provides uniform hardness; greater depth of hardness.
3. Stable; non-sludging.
4. Wets out steel surfaces rapidly.
5. Though fast in heat absorption, it will not distort or crack work.
6. Meets needs for flash, fire and viscosity.
7. Priced right for volume requirements.

For full data on HOUGHTO-QUENCH G and description of pressure quenching and cooling systems, write Dept. M.

E. F. HOUGHTON & CO.

Chicago - PHILADELPHIA - Detroit

HOUGHTO-QUENCH "G"

"ROCKWELL"
Motorized
HARDNESS TESTER

Model 3-QR "ROCKWELL" Motorized Hardness Tester

Anyone capable of doing any kind of precision inspection can quickly and readily learn to use our Motorized Model, the readings of which are entirely uninfluenced by variations in thickness of pieces tested. These testers are intended for high quantity inspection testing of small parts or other parts that can be quickly handled and quickly located in position for testing. As even our hand-operated machines make tests rapidly, the speed advantage of motorizing the tester becomes relatively smaller when very large pieces or pieces entailing slow manipulation into position are to be tested. If you buy the Motorized "ROCKWELL" Tester for quantity testing, it will do other hardness testing for you as easily and accurately as a hand machine.

WILSON
MECHANICAL INSTRUMENT CO., INC.

379 Concord Ave., New York

ROCKWELL
TRADE MARK REG. U. S. PATENT OFFICE
HARDNESS TESTER

Model 3-PR "ROCKWELL" Hardness Tester

In toolrooms, metallurgical laboratories and for any place where testing is intermittently done, our hand-operated testers are customarily used. Even for continuous inspection testing, if the pieces are of assorted shapes or are at all heavy or clumsy or are of such peculiar shape that they take any real amount of time to position for test, there is no advantage in using the more expensive motorized machine, as no real gain in speed over our hand-operated machine could be expected where it takes several times as long to properly position a piece for test as is required for the machine to make the test.

Let nothing but your actual conditions and requirements decide between hand-operated and motorized "ROCKWELL" Hardness Testers.

WILSON
MECHANICAL INSTRUMENT CO., INC.

379 Concord Ave., New York

TRADEMARKS of LEADERSHIP

FIRE CLAY DIVISION

Tayco-Super, Tyson, Tiger and Tiger Steel Brick — Taylor Quality Shapes — Monocrete, Plastayco and Tayco Refractory Cements

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Brick — Shapes — Plastics Cements — Glass House Refractories Feeder Parts — Batts and Kiln Furniture Hydrocast

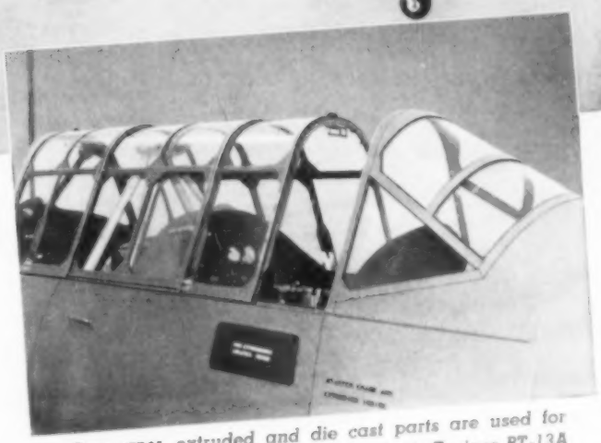
For over three-quarters of a century we have been leading Refractorers to Industry. We approach the future confident that users of Refractories will find, in these simple trade marks, a guarantee of satisfaction.

CHAS. TAYLOR SONS Co.

MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U. S. A.

DOWMETAL MAGNESIUM

Vultee Basic Trainer, BT-13A, fabricated by Vultee Aircraft, Inc., Vultee Field Division, Vultee Field, California



DOWMETAL extruded and die cast parts are used for the cockpit canopy of the Vultee Basic Trainer BT-13A

The use of magnesium alloys in the extruded form is progressing rapidly. In airplane construction, for example, such parts include extruded sections of DOWMETAL* for seats, panel stiffeners, fillers, various cabin parts and for canopy framing, such as the cockpit canopy for the Vultee Basic Trainer BT-13A, shown above.

DOWMETAL, unique as a weight-saving metal, is readily fabricated by all the usual methods. Technical data is available. Dow invites consultations.

*Trade Mark Reg. U. S. Pat. Off.

A CITATION OF USEFULNESS

It is gratifying to Dow that magnesium is playing such a vital role in the furtherance of our security program. Millions of pounds of this metal, produced by Dow, are now going into aircraft and other defense equipment. Placement on the priority list is, truly, a citation of distinction—evidence of indispensable usefulness which industry understands and appreciates.

THE DOW CHEMICAL COMPANY
MIDLAND MICHIGAN

New York City, St. Louis, Chicago, San Francisco,
Los Angeles, Seattle, Houston

CASTINGS • FORGINGS • SHEET • STRIP • PLATE • EXTRUSIONS

TRADE MARK
DOWMETAL
MAGNESIUM ALLOYS

LIGHTEST OF ALL STRUCTURAL METALS

Look to the LEADER

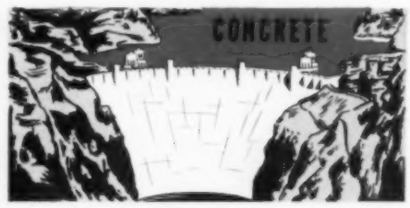
for the really important developments in physical testing methods and equipment

PIONEER builders of many of the machines which are now standard equipment for testing soils, asphalt, concrete, wood and metals; producers of the accepted testing machine for the

cement and concrete industry; and developers of the high magnification stress-strain recorder, Baldwin Southwark has contributed materially to

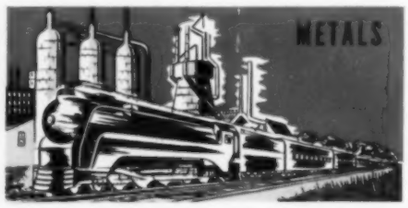
the advancement of physical testing.

Our present line includes a wide variety of physical testing machines and instruments for both static and



dynamic strain measurement and stress analysis.

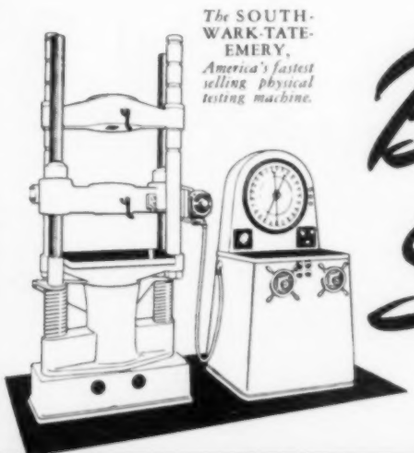
But our work is not done—develop-



ment will continue. With the cooperation of Industry we are applying to the development of testing equipment the knowledge acquired by our organization through long years of experience in the materials testing field.

Baldwin Southwark Division, The Baldwin Locomotive Works, Philadelphia; Pacific Coast Representative, The Pelton Water Wheel Co., San Francisco.

WRITE TODAY FOR BULLETIN 107



The SOUTHWARK-TATE-EMERY, *America's fastest selling physical testing machine.*

Baldwin Southwark

DIVISION OF
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THE BALDWIN GROUP

Practical Helps for Heat Treaters

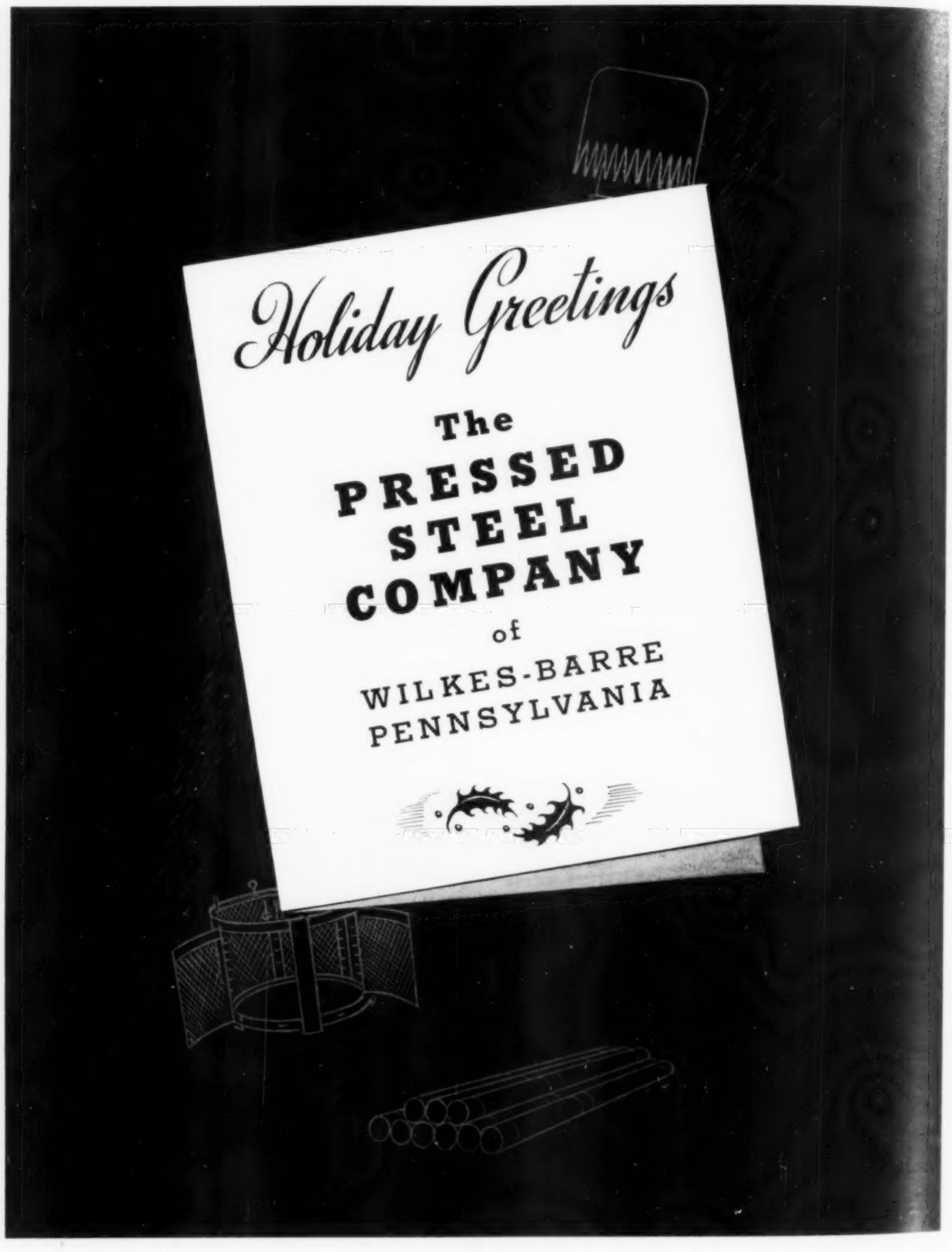
1 Furnaces for Armament is packed with facts and practical information on the types of heat treating equipment best suited to production of cartridge cases, gun mounts, clips and links, tank parts and other government work. It is practical, helpful and factual because the Lindberg organization, its publishers, is a thoroughly practical group with a vast background of practical experience gained in the world's largest commercial heat treating plant. If you are planning on government contract or sub-contract work, whether it's the heat treatment of aluminum fuselage sections, the nitriding of tank parts, or the production of 20 mm. cartridge cases, a copy of FURNACES FOR ARMAMENT should be on your desk.

2 Heat Treating Hints goes into its third year of publication with wide and enthusiastic acceptance of over 8000 heat treaters and metallurgists throughout the country. The publication is unique in that it puts onto paper the actual shop methods of experienced heat treaters. All articles, whether on straightening, types of tongs to use for high speed parts, or the ageing of gages, for example, are strictly "how to do it." It is published without charge for Heat Treaters by Heat Treaters, and your name will be added to the mailing list upon request.

3 Supplementing the publication is the full length sound and color HEAT TREATING HINTS Movie. Scenes in the film show the actual heat treating operations going on, with the editors of Heat Treating Hints in action at their furnaces, quench tanks and straightening presses. The movie contains no advertising. A pamphlet is available giving complete instructions on how to arrange for the showing of the Heat Treating Hints movie at your plant or chapter meeting.

LINDBERG
ENGINEERING COMPANY
2450 W. HUBBARD ST., CHICAGO

LINDBERG FURNACES



BRANCH OFFICES: 337 Curtis Bldg., Detroit; 1914 Vermont Ave., Toledo; 205 Engineers Bldg., Chicago; 254 W. 31st St., New York

PRESSED STEEL COMPANY PRODUCTS: Carburizing and Annealing Boxes, Thermocouple Protection Tubes, Seamless Steel Cylinder Caps, Seamless Steel Neck Rings, Welded Alloy Tubing for High Temperature and Corrosive Application

DEMOLITION BOMBS

made of

N-A-X
High Tensile

DUCTILITY
ITS INHERENTLY FINER GRAIN
MAKES ALL THE DIFFERENCE
STRENGTH

In applications such as demolition bombs, N-A-X HIGH TENSILE is ideal, for it meets the exacting specifications set up for this important defense material. This superior low alloy steel possesses outstanding impact properties—an item of particular importance in applications of this sort.

N-A-X HIGH TENSILE has other important properties, too, that permit the fabricator to form these bombs with speed and ease. This superior low alloy steel works well in all phases of manufacture, and its outstanding ductility and forging properties combined with excellent welding characteristics make for low-cost fabrication.

In hundreds of exacting applications, N-A-X HIGH TENSILE has proved without question that it is a really superior low alloy steel. In parts or products that must operate in all kinds of weather, over undeveloped terrain, the impact and fatigue resistance of N-A-X HIGH TENSILE has given equipment longer life with lower upkeep cost.

Great Lakes engineers, who have experience covering N-A-X HIGH TENSILE in all types of applications, will be glad to assist you in the use of this outstanding low alloy steel. Telephone, wire or write for one of these engineers today. No cost or obligation.

LIST OF PRODUCTS

Hot Rolled Strip (down to 1 inch wide) . . . Hot Rolled Strip Sheets (up to 91 inches wide) . . . Spring Steel (carbon and alloy) . . . Merchant Bars . . . Forging Bars . . . Automobile Bumper Sections . . . Bar Mill Sections . . . N-A-X HIGH TENSILE Bars, Shapes, Sheets, Billets . . . Sheet Bars . . . Hot and Cold Rolled Sheets . . . Michigan Metal for Vitreous Enameling . . . Deep Drawing Quality (in all grades, widths up to 91 inches) . . . Stran-Steel Metal Framing for Residential and Commercial Construction.

GREAT LAKES STEEL CORPORATION—DETROIT, MICHIGAN

Sales Offices in Principal Cities

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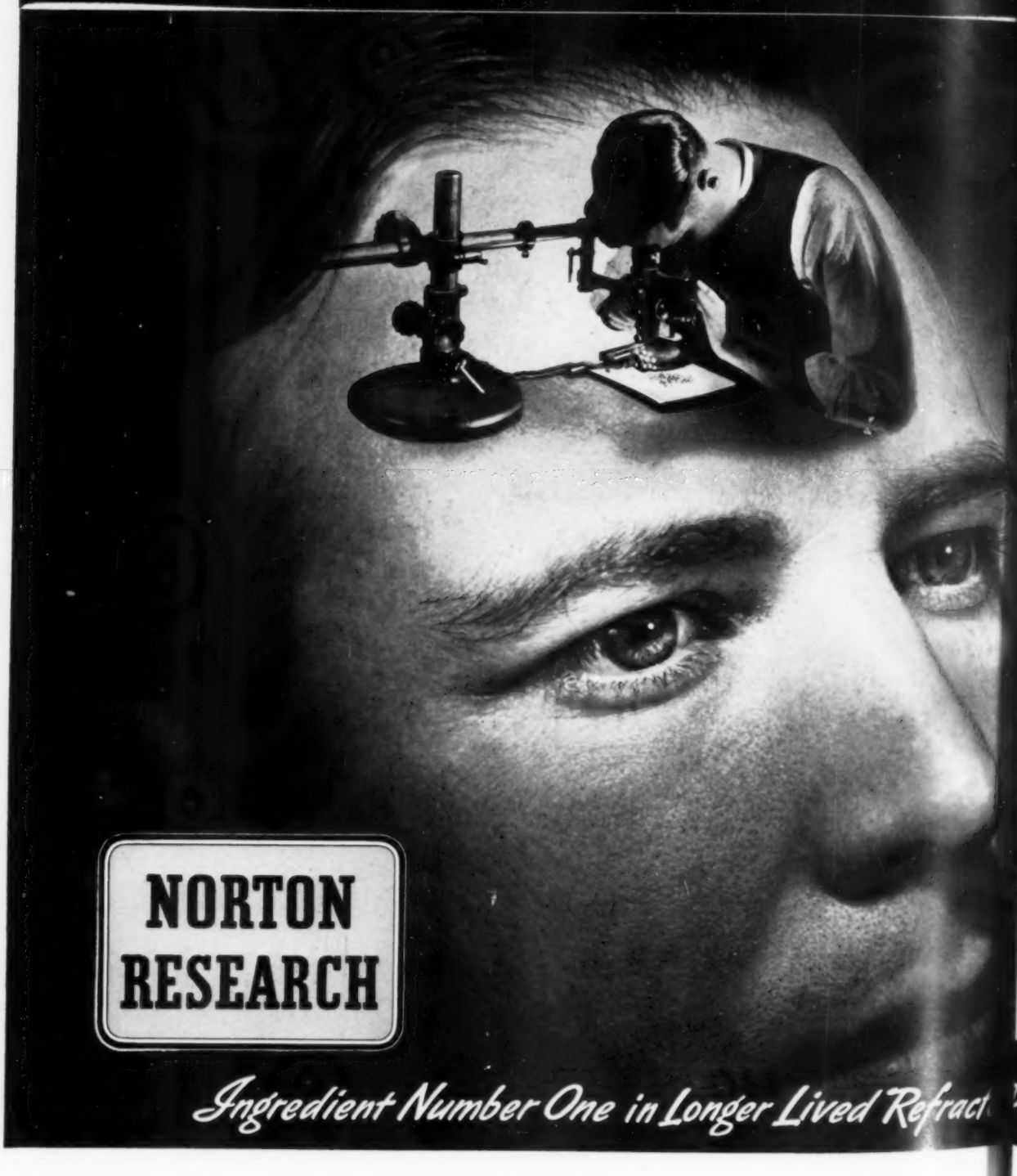
NATIONAL STEEL CORPORATION

Executive Offices, Pittsburgh, Pa.

GRAINS + BRAIN



Ingredient Number One in Longer Lived Refract

= THE LONGEST-LIVED REFRACTORY FOR YOU

Two basic Norton ingredients help you get refractory products that combine in the highest possible degree, the complex of properties you need — strength, correct porosity, resistance to extremes and variations of heat, to slag, oxidation, and other operating hazards.

One of these two ingredients is the electric-furnace-fused grains, among the hardest substances known to man, that are common to all Norton products. These grains may be silicon carbide, fused alumina or fused magnesia, depending on the conditions you must meet — but all come from the heart of electric furnaces.

The *other* fundamental ingredient, mixed with the electrically fused grains and the varying bonds, is Norton *brains*. Long-experienced field and laboratory minds determine the proper mix and shape for the closest fulfillment of all your requirements.

The most refractory substances known, plus A-1 field and laboratory research, are Norton's contributions to your refractory problems.

Products

FIRING LINE NEWS

Enduring Muffles, for Furnaces Heat-Treating Tungsten, Molybdenum

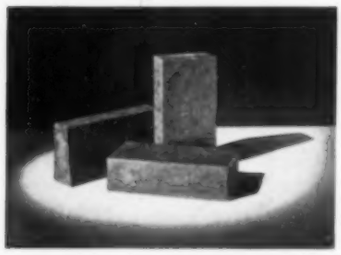
In electric furnaces operating up to 1600° C., ALUNDUM (Al_2O_3) muffles, available in all designs and sizes, provide

—electrical resistance unsurpassed by any other refractory material.

—top chemical stability, under oxidizing and other chemical conditions.

—long-lived refractoriness, without spalling, softening or deformation.

Long-term refractory costs are lowered by use of ALUNDUM muffles. Still more vital to you today, is prevention of shutdowns for rebuilding furnaces.



CRYSTOLON (SiC) Pier Brick Stand Up Under Great Heat and Heavy Loads

The double strain of constant direct exposure to elevated temperatures in enclosed chambers — plus bearing the weight of a heavy structure — shortens the life of most pier brick used in furnaces for galvanizing wire, etc. CRYSTOLON pier brick, however, can take it. Refractory without spalling, softening or deformation up to 1650° C., silicon carbide is also one of the strongest materials known to man. In longer life, and prevention of interruptions to production, it pays its way over and over.

Electrically Resistant, Chemically Stable Cores for Laboratory Furnaces

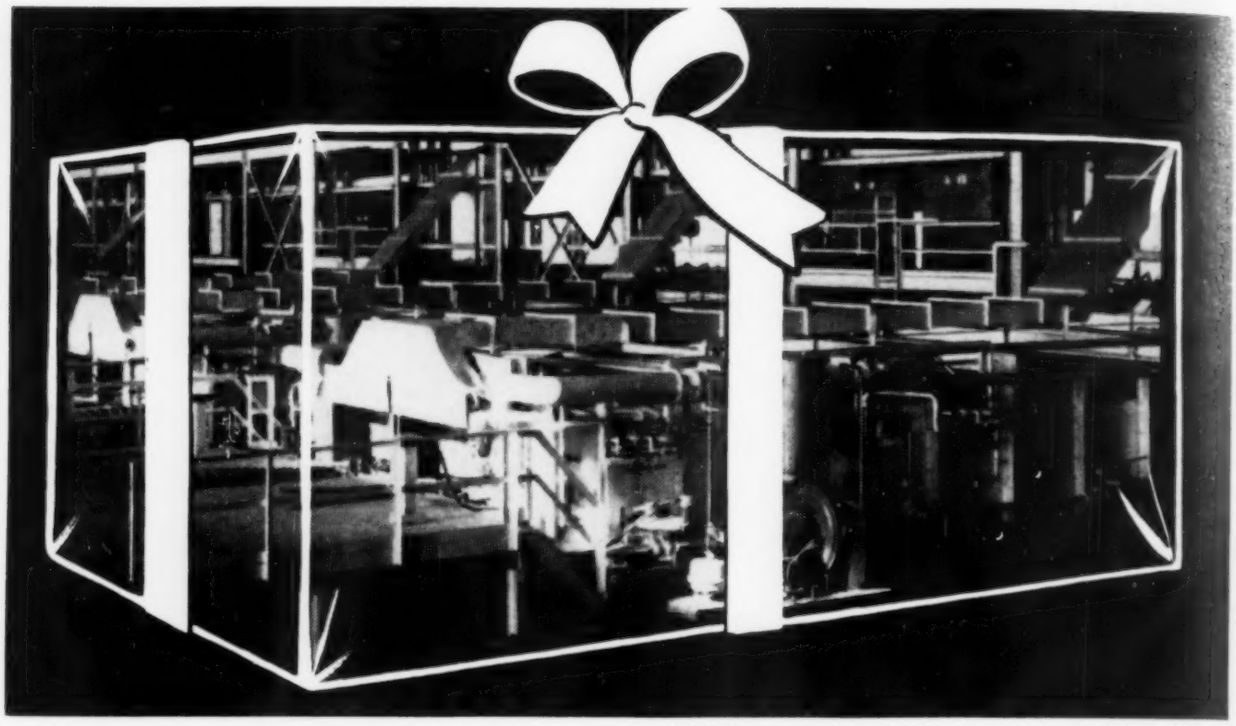
For your laboratory's combustion or incinerating furnaces, drying ovens, wire drawing, heat treating or metal melting furnaces — ALUNDUM (Al_2O_3) cores offer in the highest combined degree, refractoriness, strength, electrical resistance and chemical stability. Made in a wide variety of spirally grooved sizes and shapes. WRITE FOR USEFUL MANUAL "The Construction of Electric Furnaces for the Laboratory."

In W, Mo, Cemented Carbides — 4-Fold Furnace Tube Life

To meet today's demands for 24-hour operation at around 1700° C., with maximum refractory life to prevent shutdowns — Norton engineers recently developed a new tube for furnaces used to heat-treat cemented carbides and tungsten or molybdenum wire. Norton's RA98 furnace tubes had set the pace for long life under the most difficult operating conditions, *but the new mix, RA1139, stretches furnace life as much as from 12 weeks to 12 months.* This new mix is applicable to tubes, cores and muffles.

Refractory Shapes and Cements of CRYSTOLON (silicon carbide), ALUNDUM (fused alumina), and fused Magnesia Grains

NORTON COMPANY, WORCESTER, MASS.



GIVE YOURSELF A CHRISTMAS GIFT - -

a trouble-free F & D furnace

Probably nothing would make you happier this Christmas than the assurance that your furnace worries were ended. If so, let Flinn & Dreffein play Santa Claus with a furnace that will end your heating problem.

We will take the entire problem off your hands—design, engineering, construction and installation. Our 34 years experience in doing the complete job for many important companies has given us wealth of experience, particularly in armament work.

And we'll get it done quickly, too. So write, wire collect, or call us today for the facts.

Here are some of the furnaces we have built: forging . . . hardening . . . annealing . . . billet heating . . . drawing . . . carburizing . . . bright annealing . . . controlled atmospheres . . . scale-free annealing . . . normalizing . . . special atmosphere . . . sheet and pair . . . plate heating . . . quenching and heat treating machines . . . continuous conveyor furnaces of all kinds.

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MR. EDWARD L. BARTHOLOMEW
CHIEF ENGINEER
UNITED SHOE MACHINERY CORP.

"All of our men who are interested in Metallurgy look forward to each new issue of Metal Progress. Metal Progress can be read and understood by furnace men as well as technical metallurgists. The value of this magazine to us is the fact that it is not too technical and it therefore helps all of us to keep abreast of the times. Its advertisements help us to keep posted on new developments in Metallurgical Equipment."

THAT METAL PROGRESS DELIVERS THE practical, authoritative answers to the pressing metal problems of these times. And in October alone, they were joined by 600 other important metal men who decided that for them, too, Metal Progress was a metallurgical must.

This record-breaking circulation increase required a November print order of 15,000 copies. It underlined the Metal Progress coverage of the metal producing and metal working markets. It emphasized that the Metal Progress base advertising page rate of $100 is the best buy in the metal industry.

Be sure your 1942 advertising schedule includes these men who are making the most out of defense metals — and of Metal Progress.

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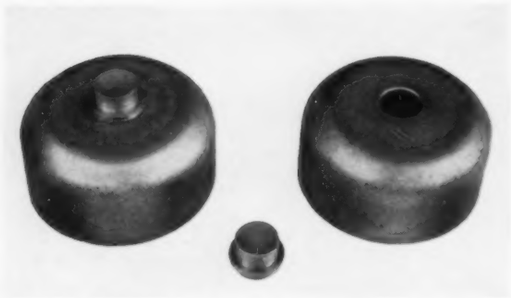
PUBLISHED BY
AMERICAN SOCIETY FOR METALS
7301 EUCLID AVENUE...CLEVELAND, OHIO

can ELECTRIC FURNACE BRAZING cut costs similarly for YOU?



FORMERLY DRAWN, this fan housing is now electric furnace-brazed at a saving of 14½%.

FORMERLY DROP-FORGED, this rocker arm costs 14% less to produce by electric furnace brazing.

FORMERLY CAST—now electric furnace-brazed, this tank spud with 2 gas-tight brazed joints costs 32% less.

FORMERLY MACHINED, this nozzle is now produced with four electric furnace-brazed joints at a saving of 25%.

• • •

Are you using—or producing—expensive castings or machined parts which electric furnace brazing could produce cheaper and better?

This cost-reducing process offers surprising advantages in unexpected places . . . in producing built-up structures at lower cost in place of screw-machine parts, forgings or drawn products . . . in joining metal parts more accurately, cheaply and in quantity.

Where and how *you* may be able to use electric furnace brazing to advantage is explained in a new helpful and informative Westinghouse booklet just off the press. Write for free copy without obligation. Ask for B-3019. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., Dept. 7-N.

J-10204

Westinghouse

ELECTRIC BRAZING FURNACES

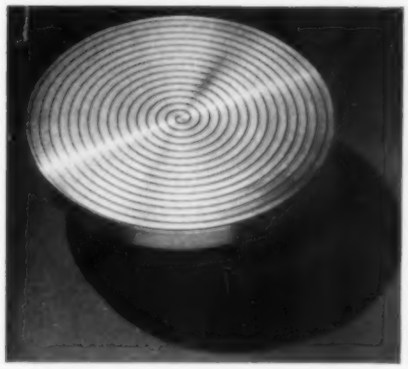
SPEED PRODUCTION

WITH

MODERN BUEHLER TESTING EQUIPMENT

MA MICROSCOPE

This sturdy table microscope provides a good flat field at magnifications of 50x to 500x. Coarse and fine adjustments are conveniently located. The lamp is permanently aligned for convenient operation. A mechanical stage may be attached to provide easy specimen coverage.



New Polishing

TECHNIQUE

The highly desirable results obtained by the use of lead laps in polishing are extreme flatness of samples, retention of inclusions and a minimum of disturbed metal. The AB lead lap set consists of two or three lead laps (which fit any 8″ Buehler polisher), two or three cast iron dressing plates, one pound of special abrasive for each lead lap, and dust proof covers for all lead laps and cast iron plates. Specimens can be taken from a fine mill file, belt surfacer or grinding wheel directly to the first lead lap. The grinding time on each lead lap is about two to three minutes. The final polish on a cloth covered lap is completed in a fraction of the usual time.

SPECIMEN POLISHER

Perfect, scratch free surfaces can readily be achieved with the well balanced AB polishers. Eight inch interchangeable discs provide ample speed latitude. Two speed ball bearing motors permit further speed selection for best polishing results. Also available with flanged bowl for table mounting.

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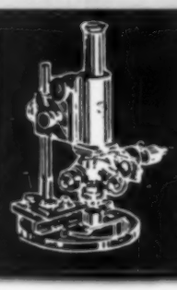

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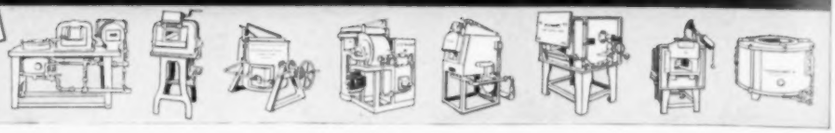

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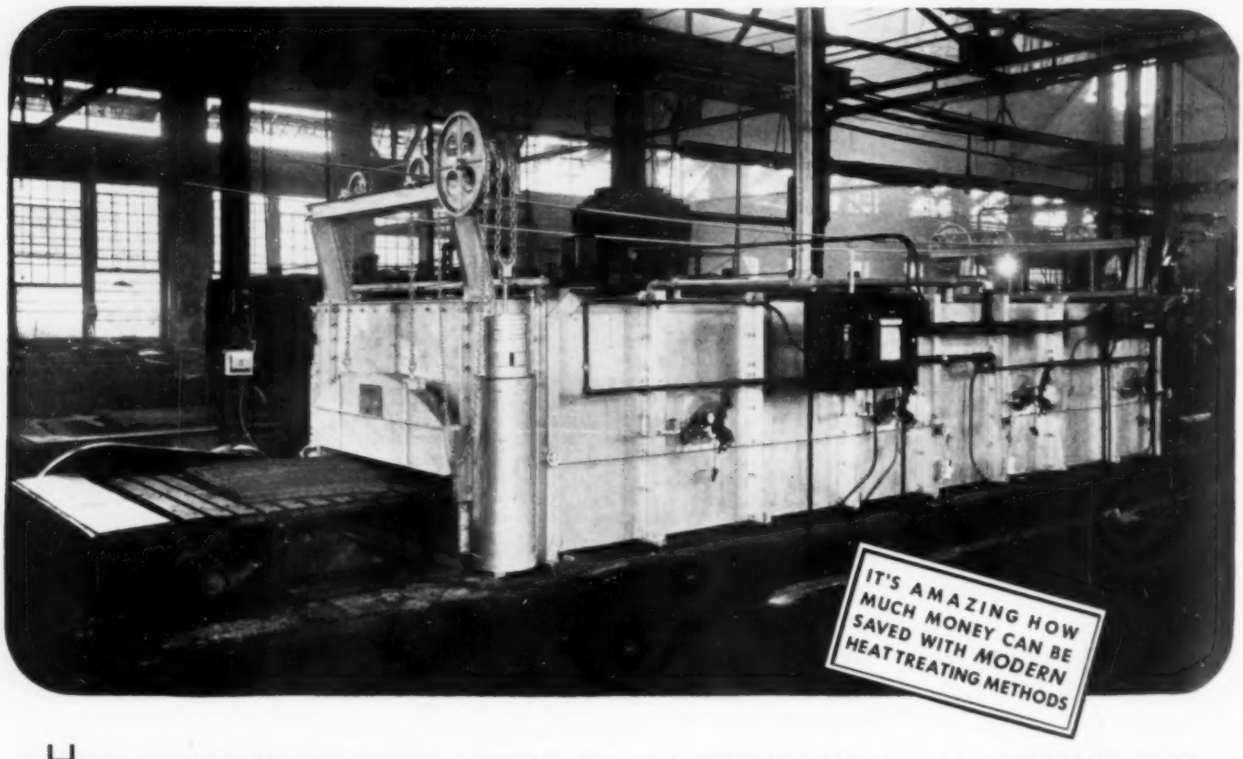

HERE'S a STEWART furnace now on the job in the Rowland Spring plant of William and Harvey Rowland, Inc., Philadelphia, tempering up to 5,000 lbs. of spring leaves per hour.

It is a traveling hearth, conveyor-type furnace with two-zone control, one recording, one indicating. Proportioning oil burners, under automatic control, give uniform heat distribution between 850 to 1100 deg. F., as required. Inside dimensions: 7 ft. wide x 45 inches high x 28 ft. long.

This STEWART furnace is typical of many Conveyor furnaces, direct-fired, or full muffle, for controlled atmosphere work, and recirculating for air draw work, now in service in the plants of leading industrial organizations throughout the continent. STEWART builds, in addition, a full line of standard furnaces.

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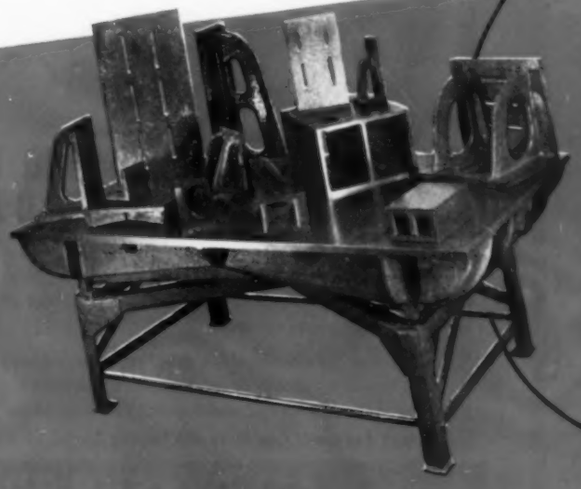

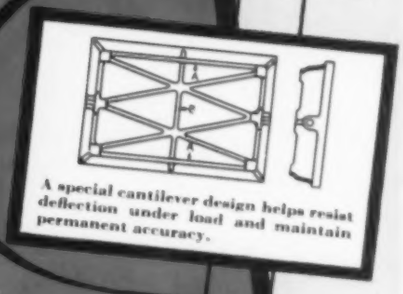

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The "beam" which can guide expectations from this new method to a "safe landing" is the continued development and sharing of accurate knowledge by the designer, the metallurgist and the manufacturer of metal powders. Specifically, a knowledge of application requirements . . . of the properties of powders and their effect upon product and processing . . . of what can and cannot be done in the present stage of this technique.

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Heat Treatment

Park-Kase

A leaflet by Park Chemical Co. contains complete information concerning a liquid carburizer of rapid and uniform penetration. Unique features and advantages of the bath are backed up with technical data. Bulletin Na-141.

Vap-O-Gas

Vapofier Corporation equipment offers the only complete, instantly usable stand-by safeguard available for use with fuel oil or gas through the same burners and manifolding. If you have heat treating equipment in your plant investigate the advantages of economy and efficiency of Vapofier. Bulletin Kd-290.

Carburizing Boxes

Carburizing boxes that reduce heat treating costs and possess stubborn resistance against heat-corrosion and hard service are illustrated in a folder released by The Pressed Steel Co. Bulletin Ce-269.

Heat Treating

Ten new ways to save time and labor with Holden Heat Treating Baths are included in a new folder released by A. F. Holden Co. Bulletin Ke-55.

Butterfly Valves

Late models of standard and wafer type butterfly or blast gate valves for the control of air, gas, steam and liquids are high-lighted in a 12-page folder just released by DS Products Corp. Bulletin Ke-234.

Thermonic Generator

Another step in induction heating progress is accomplished by the Thermonic Generator which is described in a folder released by Induction Heating Corp. Bulletin Ke-323.

SAE "Specs"

A new, completely revised wall chart of Heat Treating information, including SAE Steel specifications, typical heat treatments, etc., is offered by The Stewart Industrial Heating Div., Chicago Flexible Shaft Co. Bulletin Ne-49.

Shell Hardening

A new rapid quench for the heat treatment of high explosive shells has been developed by E. F. Houghton & Co. Bulletin Ne-38.

Testing • Control

Thermocouple Head

Thermocouple heads and parts are covered in literature by Claud S. Gordon Co. Bulletin Be-53.

Thermocouple Data

A complete manual for all thermocouple users containing 32 pages of facts about all types of these instruments has just been made available by Wheelco Instruments Co. Bulletin Ie-110.

Pocket Relationship Table

A very handy celluloid table which fits snugly in your pocket and shows the relationship between Rockwell, Brinell, and Vickers hardnesses has been prepared by Wilson Mechanical Instrument Co. Bulletin Be-22.

Non-Destructive Testing

The technique of Gamma-Ray Radiography in the non-destructive testing of metals is well covered in a 20-page illustrated booklet by Canadian Radium & Uranium Corp. Bulletin Ie-320.

Metallurgical Equipment

A complete line of the most modern laboratory equipment is shown in an attractive folder released by Adolph I. Buehler. Bulletin Ke-135.

Testing Equipment

The Southwark Line of Testing Equipment is described in a colorful new booklet released by The Baldwin Southwark Division of The Baldwin Locomotive Wks. Bulletin Ne-67.

Automatic Control

An inexpensive automatic control system for controlled heating, soak out temperature, soak out time, and rates of cooling is described in a new booklet by The Brown Instrument Co. Bulletin Ne-3.

Plating Temperatures

Temperature instruments for plating operations are illustrated and described in a new colorful 8-page folder released by The Foxboro Co. Bulletin Ne-21.

Thermocouple Head

A new Universal Enclosed Terminal Head of unique design permitting ready inspection or assembly of thermocouple without disconnecting leads, or bending thermocouple wires, is described in literature available through Arklay S. Richards Co., Inc. Bulletin Ne-330.

Metal Working • Forging

Electric Tool

An electric tool sturdy enough to drill a hole in a ¼-inch iron plate in 42 seconds, yet so handy and light as to handle delicate carving or engraving to perfection, is described completely in a folder published by Paramount Products Co. Bulletin He-315.

Cutting Tools

A very valuable little 64-page handbook released by Firth-Sterling Steel Co. tells how to make, use and maintain sintered carbide cutting tools. Bulletin Le-177.

Metal Saw

A Metal Cutting Band Saw that incorporates the very latest features for all types of metal cutting is shown in a folder just released by Wells Mfg. Co. Bulletin He-316.

Band Saws

Actual performance records of DoALL Band Saws are contained in a booklet made available by the DoAll Co., Inc. Bulletin Ae-297.

Handee Tool

The HANDEE Tool of 1001 Uses is described in a newsy 64-page book which illustrates many of its uses and presents many helpful facts about grinding, cutting, polishing and working metals. Bulletin Ie-230.

Contour Machine

An unusual file-size spiral bound book containing a wealth of information on contour cutting is offered by Continental Machines, Inc. Bulletin Ee-170.

Handling Problems

An interesting 48-page booklet packed with installation pictures showing how varied companies have licked materials handling problems is made available by the American Monorail Co. Bulletin Ie-318.

Cutting Oils

An interesting booklet, "Metal Cutting Lubrication — In Theory and Practice", has just been made available by Cities Service Oil Co. Bulletin Ec-113.

Cecostamp

A high production, impact-type stamping machine developed for forming stainless steel, thin hot work that cools quickly, embossing, and work hard to set to final shape is described in an instructive 16-page booklet by the Chambersburg Engineering Co. Bulletin Gc-132.

Cutting Oils

A comprehensive handbook which discusses the subject of metal cutting lubricants and recommends the solutions to many tough application problems is available through D. A. Stuart Oil Co. Bulletin Ke-118.

Hardsteel Drill

A new type of drill which will cut hardened steel of any type, temper or analysis is introduced in a handy little 12-page folder released by The Black Drill Co. Bulletin Ne-328.

Furnaces • Industrial Ovens • Refractories

Electric Furnaces

A catalog on electric furnaces and pyrometers has been released by the Hoskins Manufacturing Company. For anyone who does any kind of heat-treating, brazing or uses heat-resisting castings. Bulletin Hc-24.

Super Refractories

A very handsome spiral-bound 76-page catalog covering their extensive line of refractories for heavy duty service is offered by the Carborundum Co. Bulletin Ld-57.

More literature listed on following page

HELPFUL

Convection Furnaces

Batch type SC Convection Furnaces which pay for themselves in seven months are explained and illustrated in a new folder by Surface Combustion Corp. Bulletin Ge-51.

Turbo-Compressors

Spencer Turbine Co. has turbo-compressors in all sizes and types for oil and gas-fired furnaces, ovens and foundry cupolas. Special types for special purposes such as gas tight and corrosion resisting applications are also described in Bulletin Da-70.

Annealing Furnace

The interesting "Top Hat" Cover Annealing furnace, perfected by Continental Industrial Engineers, Inc., is described in a bulletin of value to furnace users. Bulletin Nc-154.

Heat Treating Furnaces

A 16-page booklet of Holcroft & Company shows and describes their line of controlled atmosphere heat treating furnaces. Bulletin Ec-203.

Insulating Firebrick

An insulating firebrick with low weight, low heat losses, and great economy is described in detail in a new bulletin by the Babcock & Wilcox Co. Bulletin Ce-75.

Conveyor Furnaces

Chain belt conveyor furnaces, their design, construction and application, are covered in a 12-page reprint of an article showing furnace details and containing over 30 illustrations of electric and fuel fired chain belt furnaces. Issued by The Electric Furnace Co. Bulletin Be-30.

Industrial Carburetor

The flame characteristic most suitable for your operation is accurately supplied by the Kemp line of Industrial Carburetors which is described in a colorful folder furnished by the C. M. Kemp Mfg. Co. Bulletin Ce-219.

Furnace Catalog

A 120-page catalog covering the complete line of furnaces and burners manufactured by The American Gas Furnace Co. is available to companies who request this book through Metal Progress on their company letterhead. Bulletin Be-11.

Convected Air Furnace

A 12-page illustrated booklet full of ideas for solving your furnace problems is now available through the Despatch Oven Co. Covers many unusual features of Despatch recirculating convected air furnaces. Bulletin Nd-123.

Bonding Silica Brick

Practical application of Tayco-40 Cement for bonding silica brick is described in a new bulletin by Charles Taylor Sons Co. which is handsomely illustrated and very interesting. Bulletin Ge-218.

Armament Furnaces

A well-illustrated and colorful folder by the Lindberg Engineering Co. tells how furnaces for armament have been developed. Bulletin Le-66.

High Temperature Furnaces

A complete line of high temperature furnaces, automatic control instruments, and a host of specialties for laboratory and general testing purposes is shown in a 32-page booklet by Burrell Technical Supply Co. Bulletin Ie-213.

Heavy Duty Refractories

A 24-page booklet showing the Norton line of heavy duty refractories with many tables of operating data and illustrations is now available through the Norton Co. Bulletin Ie-88.

Atmosphere Furnaces

A very colorful six-page folder on "Lithco" Atmosphere Furnaces with large illustrations and interesting data is available through the Lithium Corp. Bulletin Ie-319.

695 Plastic

A Highly Refractory Magnesia Chrome Plastic for Taphole Construction and Hot Repairs is described in an attractive folder just published by Basic Refractories, Inc. Bulletin Ke-192.

High-Alumina Brick

A super-duty corundum refractory which gives particularly fine results in difficult applications is described in a colorful folder by Harbison-Walker Refractories Co. Bulletin Ke-324.

Gas Burners

A complete line of Gas Burners for all purposes is described in a folder by Eclipse Fuel Engineering Co. Bulletin Ke-226.

Industrial Furnaces

A colorful folder by The Drever Co. shows annealing furnaces, clean hardening furnaces, general purpose furnaces, and auxiliary atmosphere equipment. Bulletin Ke-321.

Salt Bath Furnace

"As modern as radio-beam control" says the attractive folder put out by Commerce Pattern Foundry & Machine Co. about the Upton electric salt bath furnace. A brief but informative article on "The Importance of Temperature" by R. C. Upton is included. Bulletin Ed-266.

Carburizing

A method which is said to put a case of just the specified thickness on a variety of work . . . gears, spindles, bearing-cones, bushings, camshafts, etc. . . . is described in a new booklet by Leeds & Northrup Co. Bulletin He-46.

Tool Furnaces

Technical data on the Mahr line of tool furnaces is contained in a folder issued by the Mahr Manufacturing Co. Bulletin Ke-5.

Electric Furnaces

Economy . . . ruggedness . . . speed . . . and versatility distinguish the line of electric furnaces described in a bulletin by The Detroit Electric Furnace Div., Kuhlman Electric Co. Bulletin Hd-271.

Heat Treating

A complete line of heat treating furnaces of all types is described in a bulletin made available by the Eclipse Fuel Engineering Co. Bulletin Ne-226.

J-M Industrial Products

The new 1941 52-page illustrated edition of the Johns-Manville Industrial Products Catalog is now available, covering information and recommendations on high and low temperature insulations for many industrial needs. Bulletin De-100.

Melting Furnaces

A very handsome and complete booklet on Fisher Melting Furnaces illustrates many of the models and gives operating data. Released by Fisher Furnace Co. Bulletin Ne-195.

Vertical Furnace

Two sizes of the unusual Sentry Vertical Furnace are described in a new bulletin issued by The Sentry Co. Bulletin Ne-114.

Welding • Cutting

Electrode Driller

An electrode driller to prepare carbon or graphite rods for use as electrodes in spectrochemical analysis has been developed by the Jarrell-Ash Co. Bulletin He-96.

Thermit Welding

A new 36-page booklet describing the Thermit welding process and its applications has been published by Metal & Thermit Corp. Bulletin Ke-64.

Oxy-Acetylene Welding

A new 12-page illustrated booklet "What the Purchasing Agent Should Know About Oxy-Acetylene Welding and Cutting Equipment and Processes" has just been announced by The Linde Air Products Co. Bulletin Ge-63.

Brazing Alloys

A complete detailed story about the low temperature silver brazing alloys Sil-Fos and Easy-Flo is contained in an attractive 18-page folder by Handy & Harman. Bulletin Ke-126.

Welding Alloys

New low temperature welding alloys which bind by eutectic low temperature reaction to give stronger joints are described in literature available through Eutectic Welding Alloys, Inc. Bulletin Be-301.

Welding Stainless

A valuable, well illustrated booklet on the welding of Stainless Steels which will be a great help to anyone welding stainless is offered by Page Steel & Wire Div., American Chain & Cable Co., Inc. Bulletin Ne-86.

Brazing

Where and how you may be able to use electric furnace brazing to advantage is explained in a new helpful and informative booklet just published by Westinghouse Electric & Mfg. Co. Bulletin Ne-134.

Nonferrous Metals

Copper

A handsome 44-page folder packed with valuable information on copper and copper alloys for the mechanical industries has been made available by the Revere Copper & Brass Co. Bulletin Ke-239.

Metal Powders

An attractive booklet containing analyses of metal powders and screen sizes is published by Metals Disintegrating Co. Bulletin Ec-208.

Dowmetal Data Book

An edition containing especially significant accomplishments in the sections on "Available Forms" and "Shop Practice" has been published by Dow Chemical Co., Dowmetal Div. Bulletin Ec-215.

Steel • Iron

Wire

Callite fine wire, drawn to close tolerance and uniformly smooth in finish, is just one of the varied products described in an attractive folder released by Callite Tungsten Corp. Bulletin Le-327.

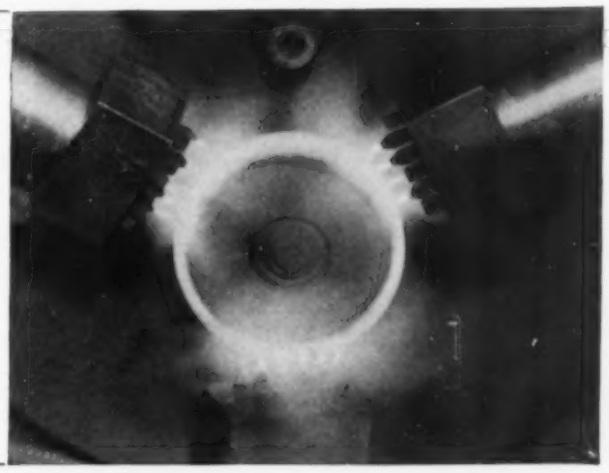
Machinery Steel Selector

A handy chart giving complete physical characteristics with variations up to 8" cross-sections, machining data, etc., on the ELASTUX group of Related Machinery Steels is available through Horace T. Potts Co., Brown-Wales Co., and Beal McCarthy & Rogers. Bulletin Ed-264.

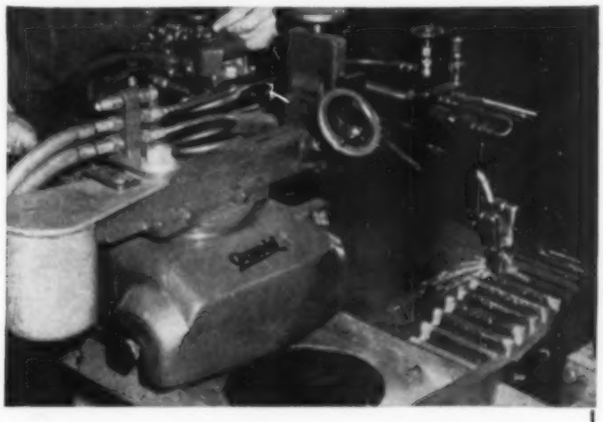
OXY-ACETYLENE FLAME-HARDENING makes wearing parts last longer . . .

1. What it is and how it's done

Oxy-acetylene flame-hardening imparts a hard case to wearing parts to make them last longer. This is done by heating the area to be hardened with oxy-acetylene flames, and then quenching with water or oil. Commonly used steels and high-tensile cast iron can be flame-hardened successfully. Small areas can be hardened by the "spot" method, using a hand welding blowpipe. Larger areas are usually hardened by mechanized equipment, using the "progressive" method or—as shown in the illustration at the right—the "spinning" method.



Unretouched view of etched cross section of a flame-hardened gear tooth.



2. What its advantages are

In many cases, oxy-acetylene flame-hardening is not only the best method, but the *only* practical method. Some of its advantages are:

- Parts of any size or shape can be hardened.
- There is no appreciable distortion.
- Toughness of the core is unaffected.
- Chemical composition of the metal is unchanged.
- Penetration can be closely controlled.
- The hardened area does not spall off.
- It permits use of cheaper base metals.
- Only a moderate equipment investment is required.

3. Typical parts being hardened

In the illustration above, Oxweld flame-hardening equipment is being used to impart a hard case to the teeth of a crane gear — at only the points where wear occurs. A few of the many other parts which are hardened—or fabricated—with the help of this oxy-acetylene process are:

Sprockets	Cams	Piston Rods
Dies	Crane Wheels	Pump Plungers
Sheave Wheels	Bearing Raceways	Crossheads
Shear Blades	Shafts	Saw Blades

Linde can supply the gases, the apparatus, and help in using flame-hardening. If you are interested in giving longer life to wearing parts, *talk it over with Linde!*

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

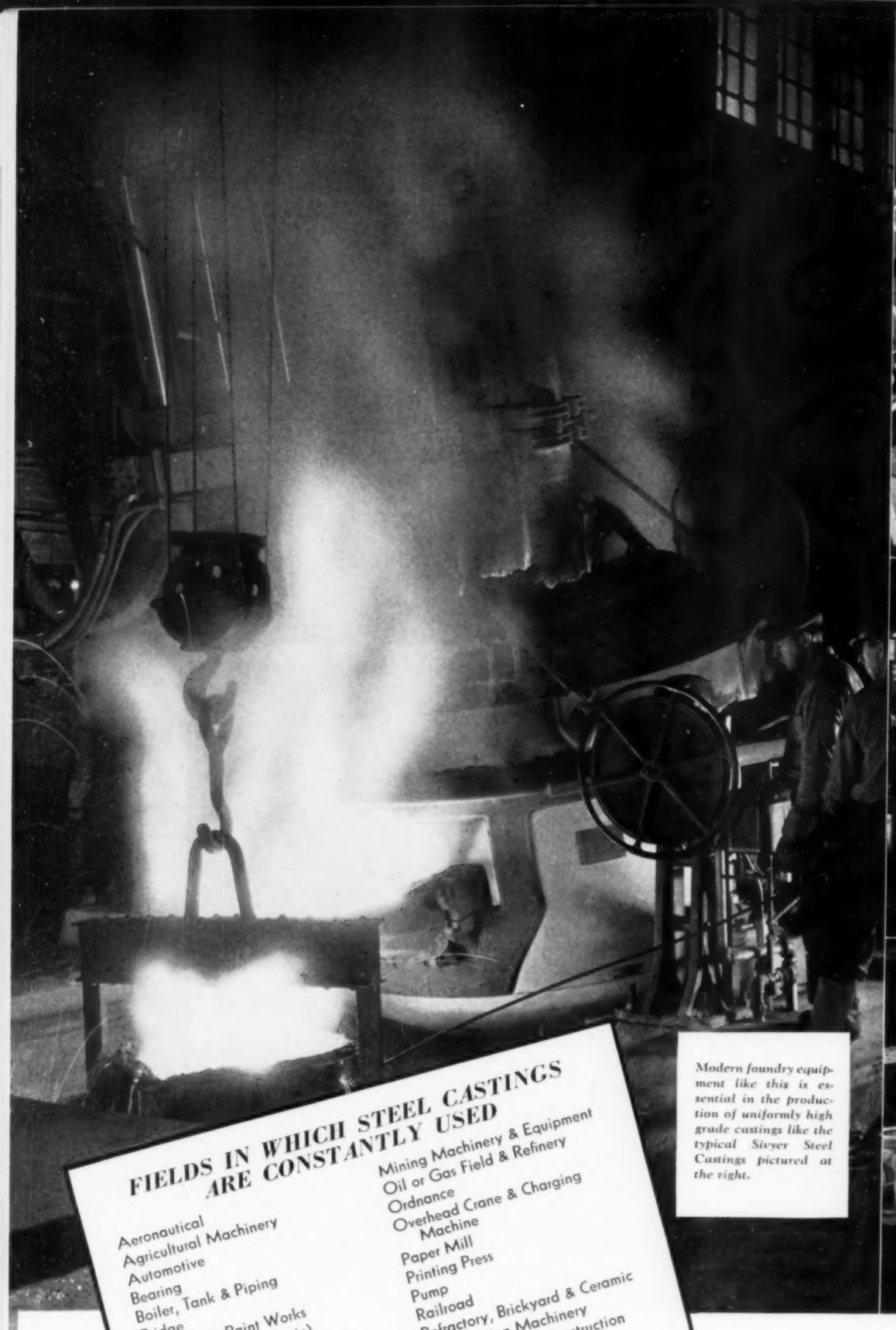
UCC

General Office: New York, N. Y. Offices in Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.



Modern foundry equipment like this is essential in the production of uniformly high grade castings like the typical Sivyer Steel Castings pictured at the right.

FIELDS IN WHICH STEEL CASTINGS ARE CONSTANTLY USED

Aeronautical
Agricultural Machinery
Automotive
Bearing
Boiler, Tank & Piping
Bridge
Chemical & Paint Works
Compressors (Pneumatic)
Conveyor & Material Handling
Crushing Machinery & Cement Mill
Dredge
Electrical Machinery & Equipment
Elevator
Engine
Food Processing & Packing Plant
Foundry Machinery & Equipment
Gas Producer & Coke Oven
Gears
Heat Treating Furnace & Equipmen
Hoist & Derrick
Iron & Steel Industries
Metallurgical Machinery
Mining Machinery & Equipment
Oil or Gas Field & Refinery
Ordnance
Overhead Crane & Charging Machine
Paper Mill
Printing Press
Pump
Railroad
Refractory, Brickyard & Ceramic
Refrigeration Machinery
Road & Building Construction
Rubber Mill
Ship & Marine
Shoe Machinery
Smelting Plant
Spray Painting Equipment
Steam Turbine
Street, Elevated, & Subway Cars
Textile Machinery
Valves, Fittings & Piping
Well Drilling Equipment

Detroit, Michigan
Detroit Steel Casting Company
4069-4140 Michigan Avenue. LAfayette 5

Houston, Texas
Texas Electric Steel Casting Company
Bringhurst & Gillespie. Fairfax 8117

Milwaukee, Wisconsin
Sivyer Steel Casting Company
1675 S. 43rd St. MItchell 442

Cleveland, Ohio
Crucible Steel Casting Company
Almira & West 84th. WOodlawn 4613

Steel Castings

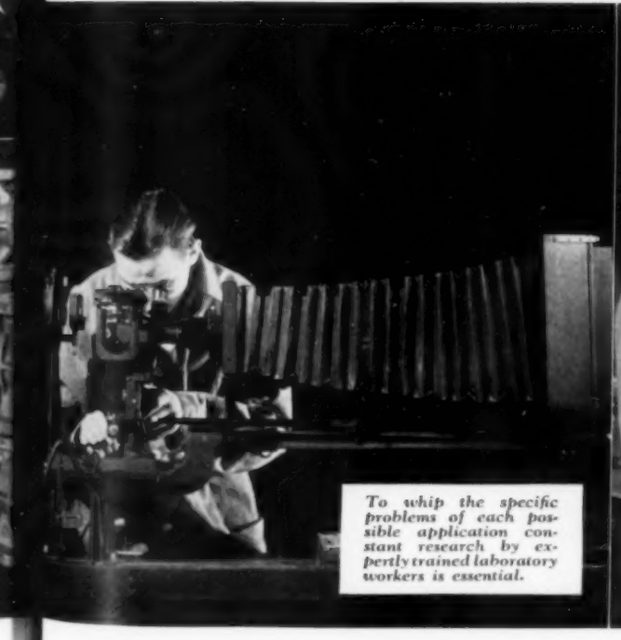
THEIR PLACE IN MODERN INDUSTRY!

Today, more and more manufacturers are using steel castings and building better and faster through their use. Companies with defense orders are saving the time required in machining, fitting and assembling by letting members of this foundry group solve their casting problems. Elaborate assemblies, once fabricated by other methods, are now — by casting — being reduced to single units . . . units less costly . . . safer . . . possessing maximum strength with minimum weight, wide range of mechanical properties, low finishing costs, high fatigue resistance and long life.

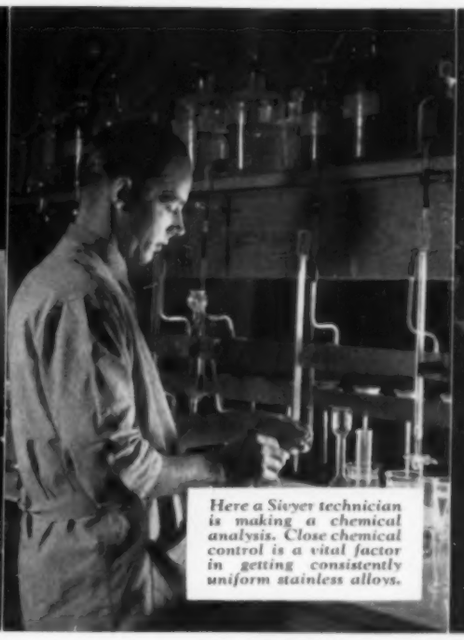
Sivyer Stainless Steel Castings Require Special Technique

To produce high grade corrosion resistant castings, — so valuable in lowering maintenance costs in paper and pulp mills, power plants, food plants and various chemical industries — requires specialized factory technique. Since each application is a special job, this technique must cope with special requirements and produce castings of mediums best suited to meet the need. Such a technique has been developed at the Sivyer Steel Casting Company. Its results and success are apparent in many phases of modern industry.

MILWAUKEE **SIVYER STEEL CASTING COMPANY** CHICAGO



To whip the specific problems of each possible application constant research by expertly trained laboratory workers is essential.



Here a Sivyer technician is making a chemical analysis. Close chemical control is a vital factor in getting consistently uniform stainless alloys.

Effect of temperature and heat treatment is another consideration in selecting the proper corrosion resistant steel.

Indianapolis, Indiana
Electric Steel Castings Company
Speedway. Belmont 0400

Buffalo, N. Y.
Strong Steel Foundry Co.
51 Norris St. Riverside 2700

Newark, New Jersey
American Steel Castings Co.
Avenue "L" and Edwards Street. Market 3-5464

Toledo, Ohio
Unitcast Corporation, Steel Casting Division
Front and Millard Avenue. POntiac 1545

Philadelphia, Pa.
Dodge Steel Company
Tacony. MAYfair 1650

Rochester, New York
The Symington-Gould Corporation
Genesee 101

Tulsa, Oklahoma
Oklahoma Steel Castings Company
1200 N. Peoria. 5-9286

WYCKOFF DRAWN STEEL COMPANY

First National Bank Building, Pittsburgh, Pa.
3200 South Kedzie Avenue, Chicago, Illinois

Mills at Ambridge, Pa., and Chicago, Ill.
Warehouse Stocks in Principal Cities

Manufacturers of Carbon and Alloy Steels . . . Turned and Polished Shafting . . . Turned and Ground Shafting . . . Wide Flats up to 12 inches by 2 inches

BOOKS

IT IS impossible to carry a complete knowledge of metals in your head.

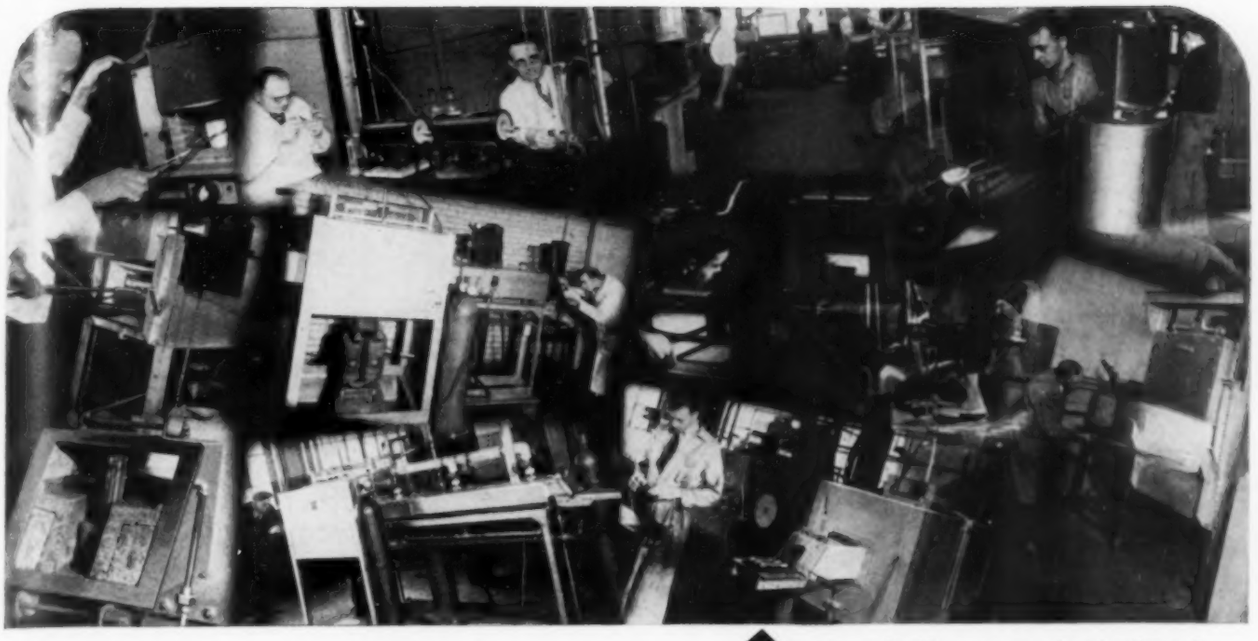
It is possible to have books in your library which cover many phases of your industry completely and well.

The books listed below do just that. Look them over and then write for complete details. We'll be glad to tell you more about them.

Carburizing Symposium
Open-Hearth Steel Making
Engineering Alloys
Book of Stainless Steels
Physical Testing of Metals
Steel Physical Properties Atlas
Metallurgical Dialogue
Principles of Heat Treatment
Tool Steels
The Quenching of Steels
Grain Size Symposium
Application of Science To the Steel Industry
Lectures On Steel and Its Treatment
Heat Treatment, Uses and Properties of Steel
Nitriding Symposium
Constitution of Steel and Cast Iron
Inclusions In Iron
Metals Handbook

address your inquiry to the

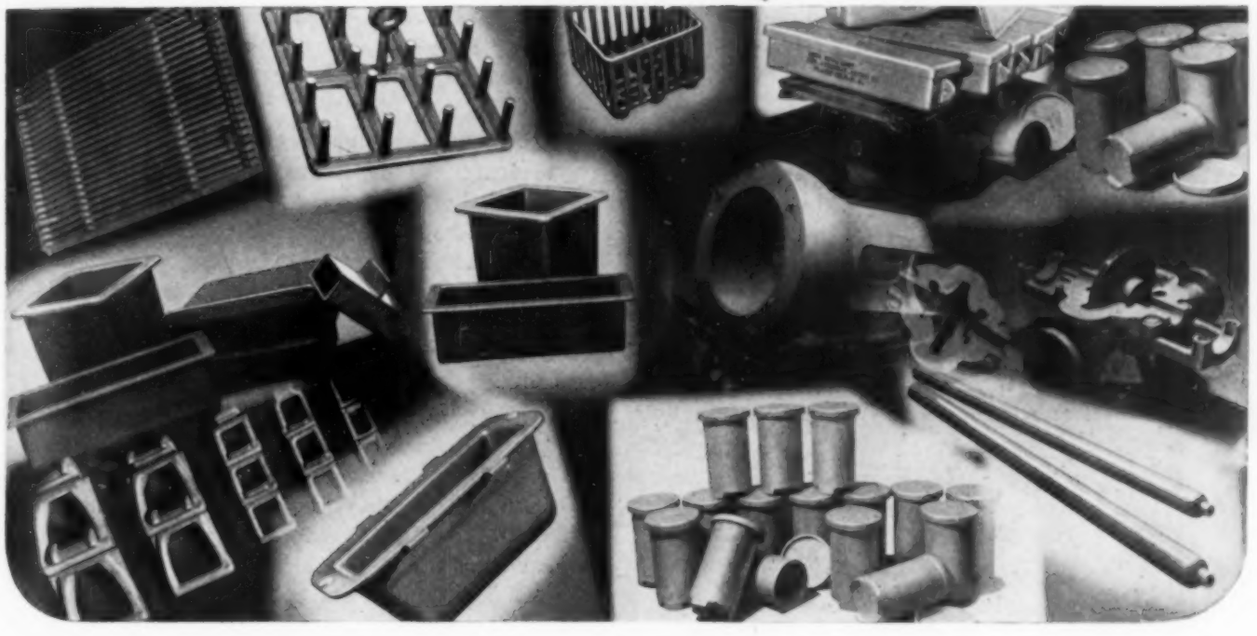
AMERICAN SOCIETY FOR METALS
7301 Euclid Avenue
Cleveland, Ohio



We're Ready!

—to work with you on your heat-treating and brazing problems and show how Hoskins Electric Furnaces fit into your picture.

—to help you with improved design of your alloy castings, and show how Alloy No. 502 lowers your heat-hour cost.



We've made electric furnaces and nickel-chromium alloys for 35 years. The furnaces are in pot and box types. The hydrogen brazing furnace has a heating chamber 6½" wide x 5", or less, high. Hoskins Furnaces are being widely purchased for metal-working munition contracts.

Our nickel-chromium alloys are made as castings, and as rolled rod. To insure uniform composition and properties, all these alloys are melted in high frequency furnaces. The performance of these alloys will please you. We invite your inquiry.... Hoskins Manufacturing Company, Detroit, Michigan.

HOSKINS PRODUCTS

ELECTRIC HEAT TREATING FURNACES • • HEATING ELEMENT ALLOYS • • THERMOCOUPLE AND LEAD WIRE • • PYROMETERS • • WELDING WIRE • • HEAT RESISTANT CASTINGS • • ENAMELING FIXTURES • • SPARK PLUG ELECTRODE WIRE • • SPECIAL ALLOYS OF NICKEL • • PROTECTION TUBES

HEATING ELEMENT WIRE
Chromel
NICKEL-CHROMIUM

COMMERCIAL HEAT TREATERS CAN HELP YOU SPEED PRODUCTION

BOSTON
New England Metallurgical Corporation
9 ALGER STREET · SOUTH BOSTON 3313

CINCINNATI
The Queen City Steel Treating Company
2978 SPRING GROVE AVE. · KIRBY 3161

CLEVELAND
The Lakeside Steel Improvement Co.
5418 LAKESIDE AVE. · HENDERSON 9100

DETROIT
Commercial Steel Treating Corporation
6100 TIREMAN AVE. · TYLER 6-6086

Commonwealth Industries
5922 COMMONWEALTH AVE. · MADISON 0573

ELIZABETH, N. J.
American Metal Treatment Company
ELIZABETH 2-2121

MILWAUKEE
Thurner Heat Treating Co.
809 W. NATIONAL AVE. · MITCHELL 6360

NEWARK, N. J.
Foster Steel Treating Co.
220-222 CLIFFORD ST. · MARKET 3-6400

NEW YORK
Heinzelman's Heat Treating Hardening Works, Inc.
154 SPRING STREET · WALKER 5-2666

PHILADELPHIA
Lorenz & Son, Inc.
1500 N. FRONT ST. · REGENT 7722 EAST 8255

Metlab Co. (Metallurgical Labs., Inc.)
1000 E. MERMAID LANE · CHESTNUT HILL 3500

Wiedemann Machine Company
1801-31 SEDGLEY AVE. · SAGAMORE 3027
PARK 2258

PITTSBURGH
Pittsburgh Commercial Heat Treating Co.
49th St. & A.V.R.R. · SCHENLEY 6277

WORCESTER, MASS.
Massachusetts Steel Treating Corp.
118 HARDING STREET · WORCESTER 37972

IT MAY BE NEW TO YOU . . .

But it's probably an old story to your commercial heat treater. We mean the innumerable unfamiliar parts which metal product manufacturers throughout the country are being called upon to make for our constantly expanding defense program.

Your commercial heat treater is typically a technically trained metallurgist with many years of practical experience in his highly specialized field. His organization is versatile and of necessity intimately familiar with the all important shop "kinks" which frequently spell the difference between success and failure in heat treating results.

Equipment in present day commercial heat treating plants is at least equal and usually superior to that found in good manufacturing plants generally. His prices must bear a logical relationship to actual costs or he could not have remained in business for the many years you have known him as a friend and neighbor.

In these times when you must have immediate action, consult your commercial heat treater first and probably you will find it efficient and economical to give him your business. If not he will help you with his training and experience without obligation on your part.

New Aluminum Industries, Inc., Plant Uses DESPATCH FURNACES

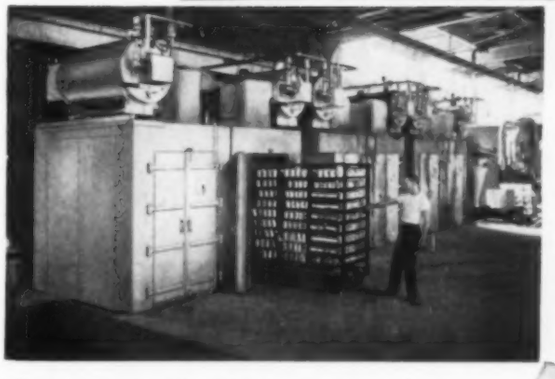
Mr. Walter J. Klayer, Chief Metallurgist of Aluminum Industries, Inc., Cincinnati, O., explains his choice.

National Defense placed a titanic production problem before aluminum and magnesium alloy fabricators. Here at the Aluminum Industries' plant we wasted no time expanding our plant to accommodate the increased demands. The increased production demanded that we enlarge our heat treating facilities with furnaces equipped with scientific control of heat cycles and capable of absolute temperature uniformity within the work chamber. Our knowledge of the Despatch design and our experience with Despatch furnace performance assured us that Despatch furnaces were the right choice.

Accurate — Uniform — Dependable — Economical Heat Treating

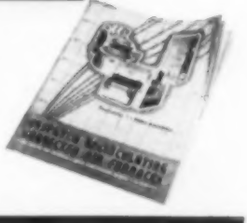
Despatch furnaces are designed to give top heat treating performance thru years of constant service. Mr. Klayer, like many others, has discovered that the design and the rugged construction of Despatch furnaces is unique; that Despatch furnaces are uniform; speedy and economical to operate; that their superiority is apparent. That is why Despatch furnaces are so often chosen when new heat treating equipment is carefully purchased.

Top—*Shown in foreground are the two Despatch pot type solution heat-treating and annealing furnaces. These furnaces can be used for heat treating either aluminum or magnesium alloy sand and permanent mold castings.*



Bottom—*A battery of 6 gas-fired batch type Despatch ovens used for precipitation heat-treating (low temperature aging) of Permite aluminum and magnesium alloy sand and permanent mold castings. This is only one of several batteries of heat-treating ovens of this type in use at this large foundry.*

Whether heat-treating aluminum, magnesium alloys, brass or other non-ferrous castings, forgings, sheets or shapes, Despatch Convected Air Furnaces suit the requirements perfectly.



FREE — WRITE FOR BULLETIN NO. 81-F

DESPATCH OVEN COMPANY MINNEAPOLIS, MINNESOTA

DEFENSE ORDERS

demand that machines stay on the job. KEEP YOUR MACHINERY ON THE JOB by hard facing the wearing parts with COLMONOY.

Sure! They are worn. They've had tough going these last few months. But there's no need to scrap them.

You can resurface those worn parts, at very low cost, with the proper grade of COLMONOY, and the parts cannot only be used again but they will outwear and outperform unsurfaced parts many times over.

COLMONOY is the easiest of all hard-surfacing alloys to apply. There is a grade for every hard surfacing requirement. Use COLMONOY to recondition worn lathe points, dogs, chip breakers, drill flutes, thrust bearings, screw machine fingers, forming and drawing edges, centerless grinder rests and other parts.

WRITE TODAY

Get our Catalog and information regarding specific installations.

WALL-COLMONOY CORP.

Sixth Floor, Buhl Bldg., Detroit, Mich.

558 W. 54th St. NEW YORK — 625 W. Jackson Blvd. CHICAGO — 208 Midco Bldg. TULSA

3155 Seneca St. BUFFALO — 123 W. Philadelphia St. WHITTIER, CALIF.

COLMONOY
Hard Surfacing Alloys and Overlay Metals

ZIVSTEEL

To those whom we have served in the past

And to those whom we may have the pleasure of serving in the future, we extend

Season's Greetings

ESTABLISHED 1911
ZIV STEEL & WIRE CO.

High Grade Tool Steel

ZIVCO TRADE MARK

Chicago — Detroit — Indianapolis — Milwaukee
St. Louis — Calumet, Mich.

a complete stock of standardized

INDUSTRIAL THERMOCOUPLES

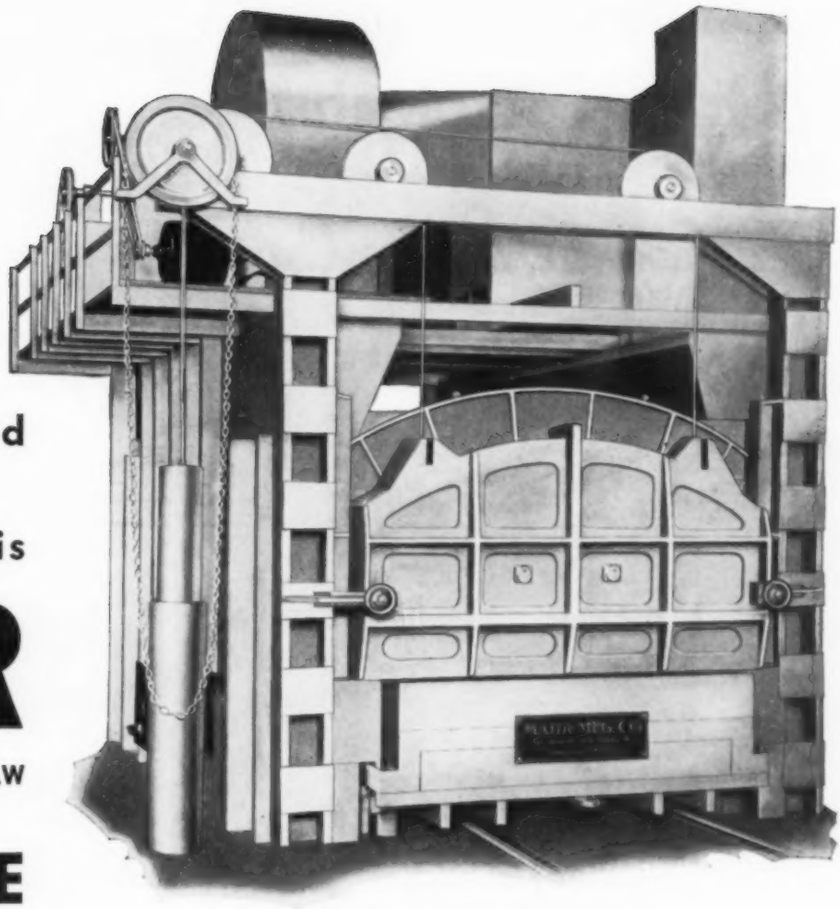
and their accessories

for all makes of pyrometers

THERMOCOUPLES LEAD WIRE
THERMOCOUPLE WIRES
INSULATORS TERMINAL HEADS
CONNECTORS
PROTECTION TUBES

ARKLAY S. RICHARDS CO., INC.

72 Winchester St. Newton Highlands, Mass.



Many new . . . and
EXCLUSIVE
features make this

MAHR

RECIRCULATING • AIR DRAW
STRESS RELIEF

FURNACE

of immediate interest to Defense Plants!

MAHR

is making astonishingly prompt deliveries on heat treating equipment of all kinds, due to our large trained personnel and manufacturing facilities. For over 25 years, the name MAHR has represented the most advanced and efficient designs in furnaces of all kinds.

Insures rapid and uniform heating through the use of large volumes of recirculated air . . . Recirculating fans of insulated alloy construction are so placed that long duct runs are eliminated, thus giving close connections for duct work and making possible close control of dampers for recirculation and air intake for cooling cycles.

Distribution ducts in heating chamber are constructed of special refractory design, thus eliminating the necessity of costly alloy and reducing maintenance costs . . . All of the features of MAHR standard car type construction are incorporated in this furnace, assuring the use of a unit with rugged construction, efficient operation and long service-life.

WRITE US TODAY for bulletins and detailed information on any furnace installation. Car bottom, batch, continuous, rotary, annealing, carburizing, stress relief, nitriding, etc. Atmosphere generators.

DIAMAHR

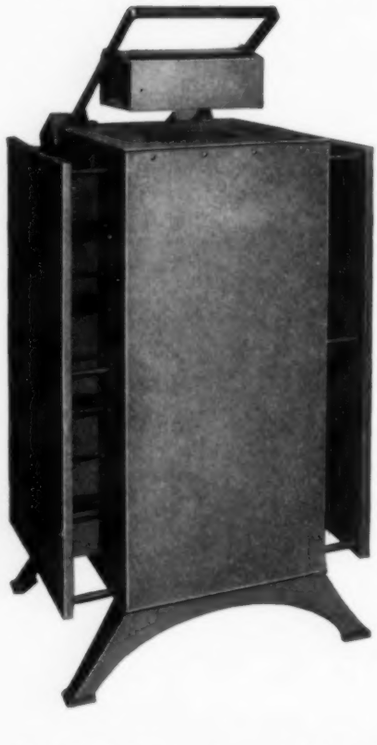
MAHR MANUFACTURING CO.
DIVISION OF DIAMOND IRON WORKS, INC.
MINNEAPOLIS, MINNESOTA, U. S. A.

HE FOOTSTEPS OF
GA X-ITE
VE MARK THE PATH
GA X-ITE

Vertical Hardening

with

Packaged Atmosphere



Long tools of high speed steel that should be treated in a vertical position can now have the advantages of Sentry *Packaged Atmosphere.* Vertical Hardening eliminates tendency of the tools to warp or change shape when hot. Sentry Diamond Blocks — *The Packaged Atmosphere Method* — automatically maintain a neutral atmosphere resulting in maximum hardness— no scale — no reduction in size — no decarburization — consistent maximum quantity.

Write for Bulletin 1023A describing two sizes of Sentry Vertical Furnaces.

Sentry DIAMOND Block

Sentry Diamond Blocks automatically maintain a *neutral atmosphere* that does not depend on analysis or manipulation. Available in sizes to meet requirements.

The Sentry Company
FOXBORO, MASS., U. S. A.

LEADING PLANTS SPEED DEFENSE ORDERS WITH OAKITE CLEANING!

Whether for cleaning steel shells, brass cartridge cases, fuzes and components, safely cleaning aluminum airplane or motor parts . . . there is a wide range of Oakite materials and methods available, one of which will do the work SAFELY, with speed, thoroughness and economy.

Send for FREE 32 Page Booklet

Since our 31 years' successful experience is at your service through our Nation-Wide Staff of representatives without cost or obligation, won't you write us today? A FREE 32-page illustrated booklet describing money-saving methods in connection with production cleaning, is yours for the asking.

OAKITE PRODUCTS, INC., 26H Thames St., NEW YORK
Representatives in all Principal Cities of U. S. and Canada

OAKITE *Certified* **CLEANING**
MATERIALS METHODS SERVICE — FOR EVERY CLEANING REQUIREMENT

FINE TOOL STEELS FOR EVERY PURPOSE

Vulcan TM-5

Tungsten Molybdenum High Speed Steel
The best all around substitute for 18-4-1 High Speed
Because—
- **It is tough**
- **Will hold a good cutting edge**
- **Is not so subject to decarb**
- **May be handled like 18-4-1 except temperatures slightly lower.**

VULCAN
CRUCIBLE STEEL CO.
ALIQUIPPA, PA.

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY
GA O'ALLOYS GA X-ITE GA O'ALLOYS GA X-ITE

Merry Christmas

YES, folks, MERRY CHRISTMAS stays as our heading. As I write, 5 A.M. Monday, following "Jap Sunday" with WAR bulletins coming in, CHRISTMAS is still a prized AMERICAN possession. Santa Claus puts so much JOY and LOVE and KINDNESS in the hearts of children that some of it sticks to even the hardest heart through life. Long after we've dumped that "Son of Heaven"—and pulled the chain—when Adolph is hogging the maggots—FATHER CHRISTMAS WILL BE GLADDENING THE HEARTS OF MANKIND. THANK GOD that our U. S. Navy is hanging up Christmas SOCKS for the Japs, while we are filling ours.

THANK GOD that it is not too late to throw that CARNAGE of class against class, greed against greed, into REVERSE. If War can bring together what Politics has torn asunder, it may be worth the horrible cost.

THIS Nation was born on a battlefield, re-united by gun powder, and may well be re-born on the WINGS of Air-Power. We were sold in and sold out of the last war. We asked for nothing and got paid double. If we bail the world out of this mess, let's get at least the slot machine and Coca-Cola concessions.

LET'S not under-estimate our Japanese adversary. The Navy doesn't talk much, but the Navy wives who've been sent home from China and the Philippines are cool, proud and CERTAIN. "It's a job to be done, and it shouldn't take long," they say.

If you haven't read Surface Combustion's outstanding new brochure on America's Defense, write them for a copy, it transcends advertising.

WE must save all possible Nickel and Chromium for National Defense. The Nickel shortage was made known before the shortage of Chromium became apparent. Immediately there rose a chorus of sponsors for "24-12" type, 24% chrome, 12% nickel alloys to supplant 35 ni-15 cr., and even the high quality Nickel-Chrome heat resistant alloys.

SOME of this outcry was charlatan stuff, flag-waving to sell inferior stuff on a "just-as-good" story. Some was premature exposition of research work with conclusions drawn from physical tests not remotely resembling service conditions. Some was wishful thinking by people ignorant of alloy applications. It was dangerous to National Defense, if it encouraged general substitution of Chrome-Nickel for Nickel-Chrome alloys.

THERE are very few places where Cr-Ni alloys can be safely substituted for Ni-Cr types in heat-treating furnace, and heat-treating container service. Principal uses of Cr-Ni types are where high sulphur atmospheres attack Nickel in oil refining and steel mill furnaces, ore-roasting, etc. There are other furnace installations where they can be used in whole or in part. General Alloys has made large tonnages of Cr-Ni alloys. We recommend them wherever experience has shown them economical.

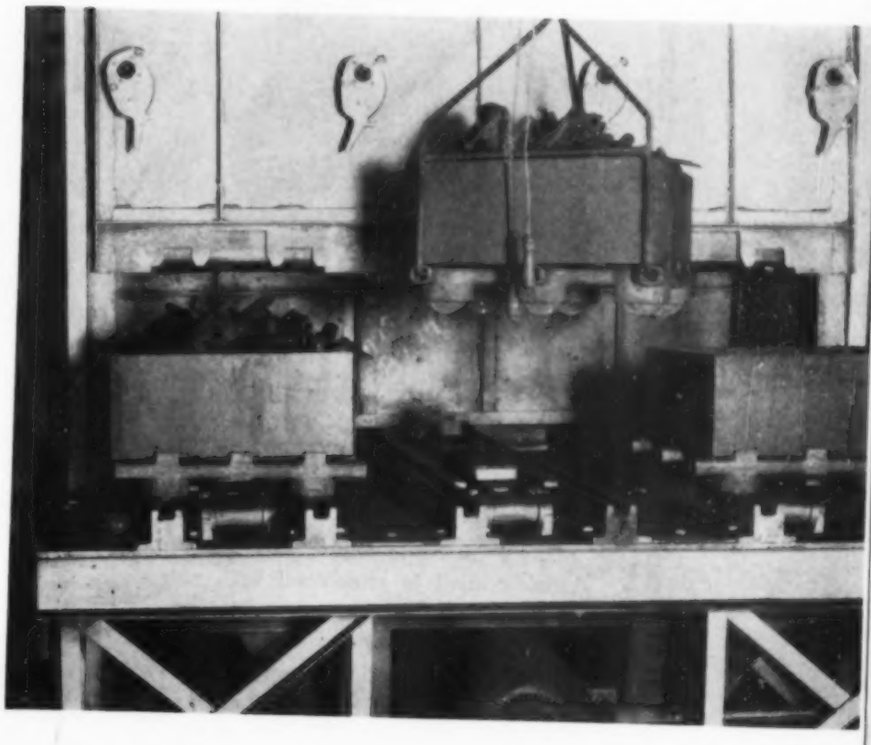
WAR has lifted us out of a depression during which most of us bought "shrewdly." Every price-selling salesman, every substitute merchant, every price-buying P.A. has hammered down alloy prices and alloy quality to the extent that instead of finding industry using costly materials in unnecessary sizes, quite the reverse is true. MUCH OF THE SUBSTITUTE ALLOY BOUGHT ON PRICE FOR DEPRESSION CONDITIONS IS GOING-to-HELL—on a HACK" when subjected to the higher temperatures, heavier loads and continuous use of NATIONAL DEFENSE REQUIREMENTS. It is not sound Defense economy to substitute weak links in the Defense chain, necessitating heavy replacement, uncertain life expectancy, and heavy stock of spares. It would take more nickel to stock the "spares" in Cr-Ni alloy for many Ni-Cr installations than the original Ni-Cr installations required, not to mention added work for already overcrowded foundries, and costly shut-downs, and break-downs for each change.

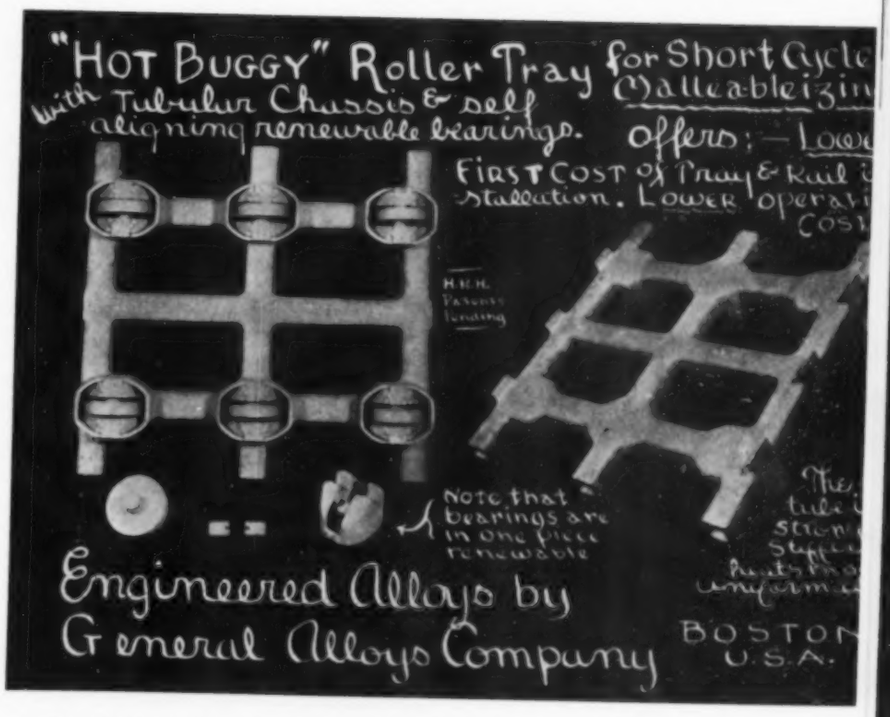
BEFORE substituting any alloys, call in G.A. and/or a couple of the old-line experienced alloy manufacturers, ask them what they will GUARANTEE. It now appears that chrome will be scarcer than Nickel. The Government may tell us what we can make; barring this, we'll recommend the lowest cost alloy that will do the job DEPENDABLY for a long enough time to justify its use IN THE NATIONAL DEFENSE INTEREST.

THE REAL WAY TO SAVE NICKEL AND CHROME is to—A. Reduce weights and wall sections to the safe workable minimum. B. Stop using alloy trays, shoes, etc., as "Ramrods". Use "Hot-Buggy" trays with lubricated rollers as thoroughly proven by SURFACE COMBUSTION CORPORATION in Malleable, gas-carburizing, and other applications. Use "Smooth-Flow" conveyor, now with 11,000 hrs. proven service. Use "Caterpillar Roller Rail", use "Spiralink Conveyor". In other words, use MODERN ALLOY ENGINEERING, by General Alloys, instead of duplicating the stuff that was born in the last war, C. Substitute lower-grade alloys, used in combination with higher grade alloys, with SERVICE GUARANTEES, when safe.

IT MAY BE HARD TO GET ALLOY REPLACEMENTS. G.A. ENGINEERING and Unequalled Foundry Practice can reduce these to a minimum.

H. H. HARRIS

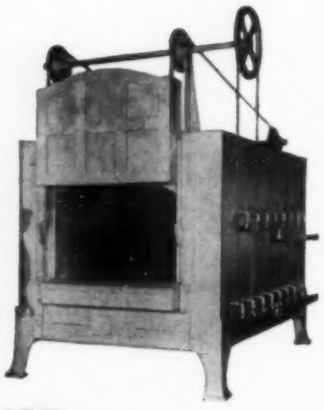



"HOT BUGGY" Roller Tray for Short Cycle Malleableizing
with Tubular Chassis & self aligning renewable bearings.
Offers:—Lower
FIRST COST of Tray & Rail Installation. Lower Operating Cost
Note that bearings are in one piece renewable
Engineered Alloys by General Alloys Company
BOSTON U.S.A.

Surface Combustion Corporation Malleablizing Furnace at Jamestown Malleable Iron Co Jamestown, N. Y. Lowest Weight of Alloy Per Pound of Material Handled of Any Malleablizing Furnace in Existence. Uses Lubricated Roller Trays Running on Simple Channel Rails.

O'ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

DO YOUR HEAT TREATING WITH ECLIPSE FURNACES



THEY ARE —

RUGGED IN CONSTRUCTION

Every Eclipse Furnace of this type —small, medium, or large—has a substantial frame to insure rigidity. The outside shell is reinforced with structural shapes, eliminating possibility of distortion even under the most severe conditions. Other parts—door, walls, bottom hearth, and burners—are designed to withstand the hard wear of heat treating.

FLEXIBLE IN CONTROL

Every Eclipse Furnace is equipped with McKee Burners and Mixing Equipment which are correctly sized to give accurate and uniform temperature control, and wide range of operation.

ECONOMICAL IN OPERATION

A combination of proper furnace design and good burner firing system provides the best means of securing economical operation. Our Furnaces are designed with these two factors in mind.

Write for Bulletin D-7

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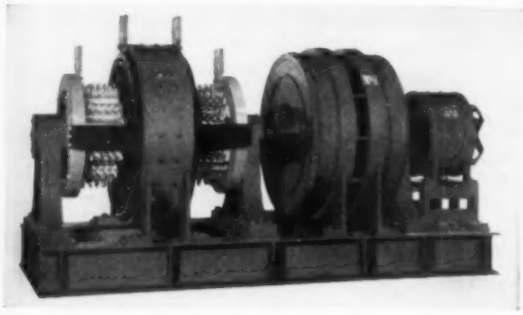
COLUMBIA MOTOR-GENERATORS

for Electro-Plating and other Electrolytic Processes



Columbia generators embody every feature essential to dependable, 24-hour operation. They are built for electroplating service in sizes of 6 to 20 volts, 500 to 20,000 amperes; for anodic treatment of aluminum in sizes of 40, 50 and 60 volts, 500 to 3,000 amperes. Columbia generators for other electrolytic processes range from ½ to 250 KW, 100 to 40,000 amperes, 6 to 60 volts.

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Today, millions of bolts, rivets, screws, and nails, are required for use in planes, tanks, battleships and other armament, as well as in homes for Defense workers. To meet this increased demand, cold heading machines must be kept running at capacity, with least possible "down time" for changing dies. For this reason, many manufacturers are specifying Jessop's NEW PROCESS, a non-porous cold header die steel which gives maximum production per die and is free of defects which result in spalling or cracking.

Write for Bulletin 141, which contains complete information on Jessop NEW PROCESS Cold Header Die Steel.

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TODAY, speedier and more efficient plating methods are highly important. Surfacing metals must be economized. To help platers find practical solutions for these and other operation problems Du Pont has available:

1. *Essential data on many types of plating.*
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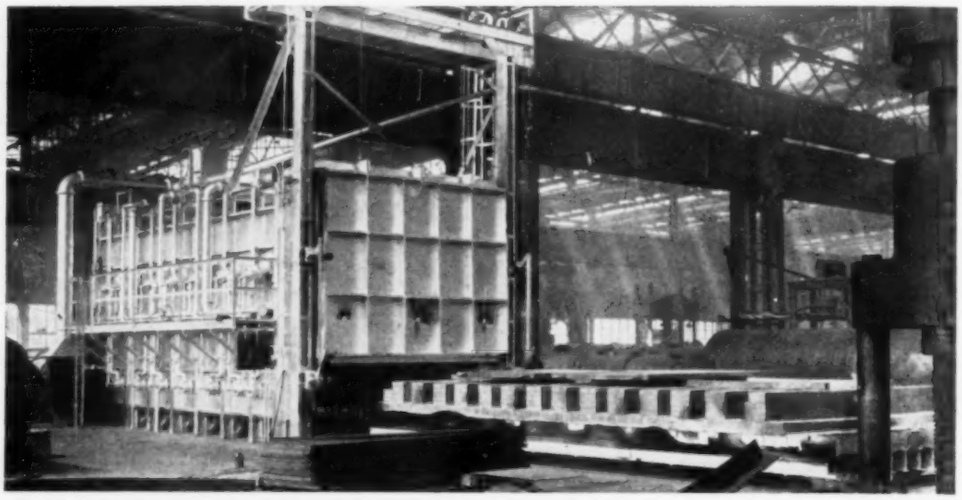

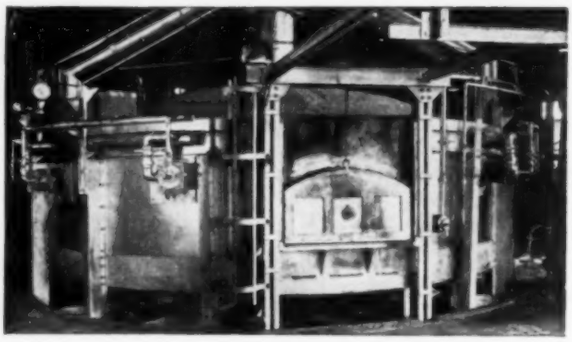

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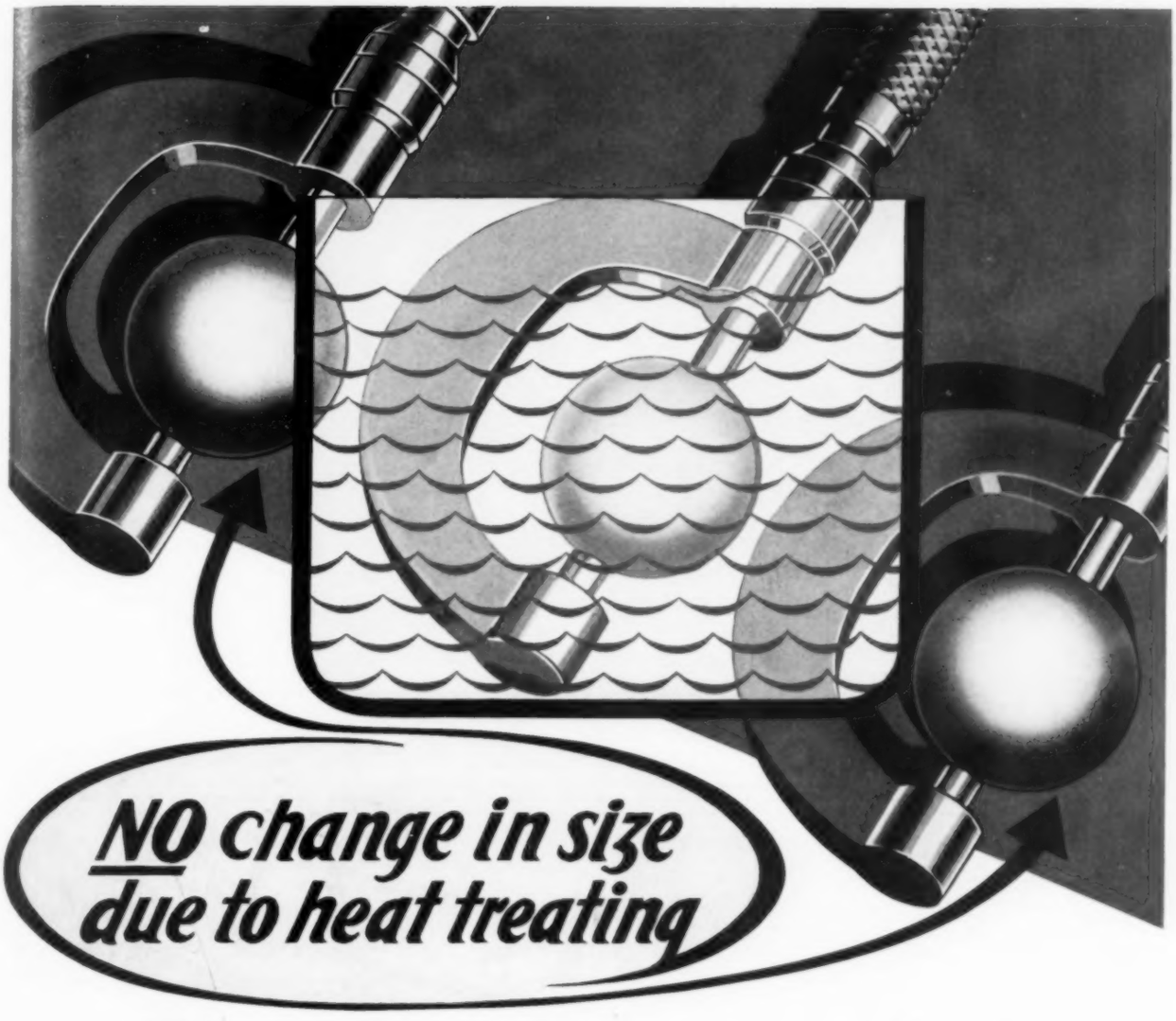

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The heating chamber measures 4" x 4" x 13¼" deep. The floor is a removable, refractory plate with moulded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26" wide x 30" high x 24" long.

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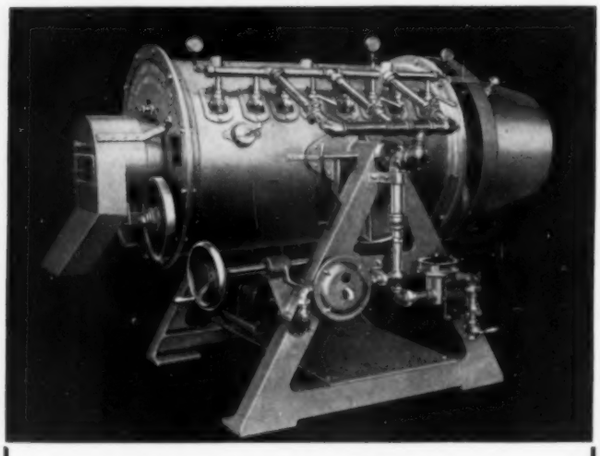

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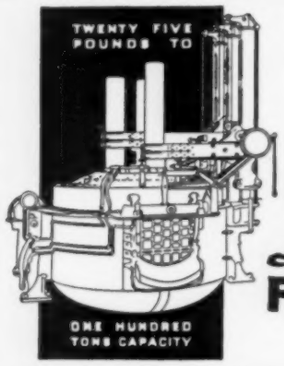
Write to Bethlehem Steel Company, Bethlehem, Pa., for your free copy of this useful booklet.

BETHLEHEM STEEL COMPANY

BETHLEHEM STEEL



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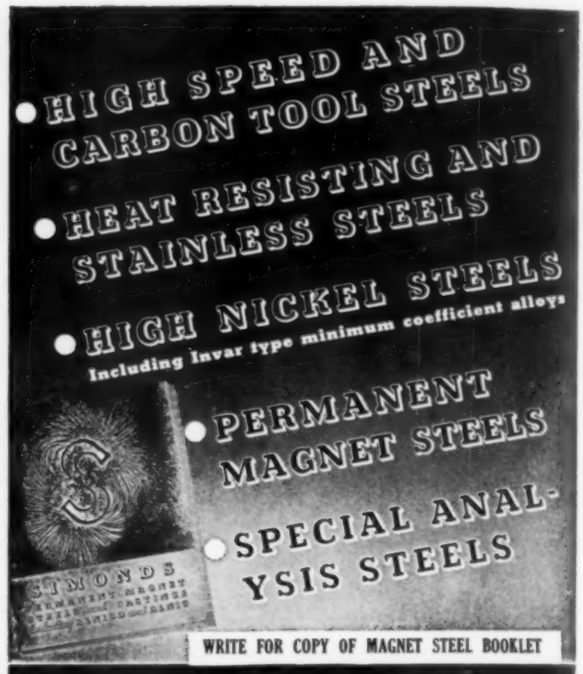
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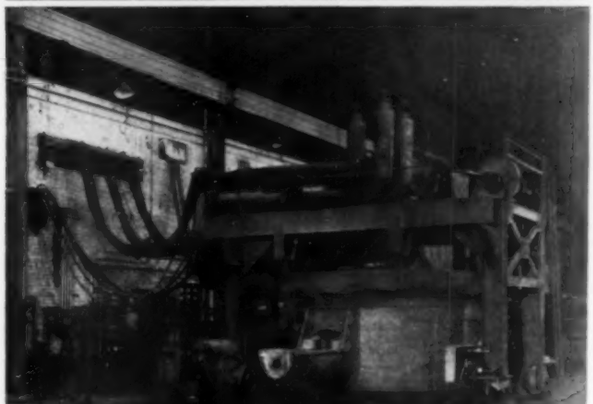

Type-10 Heroult Furnace with gantry-type removable roof for overhead bucket charging.

USE them for efficient melting and refining of all kinds of ferrous materials by either basic or acid process—including alloy, tool and forging steels, iron and steel castings. Any capacity from ½ ton to 100 tons; removable roof, chute, machine or hand charging.

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UNITED STATES STEEL

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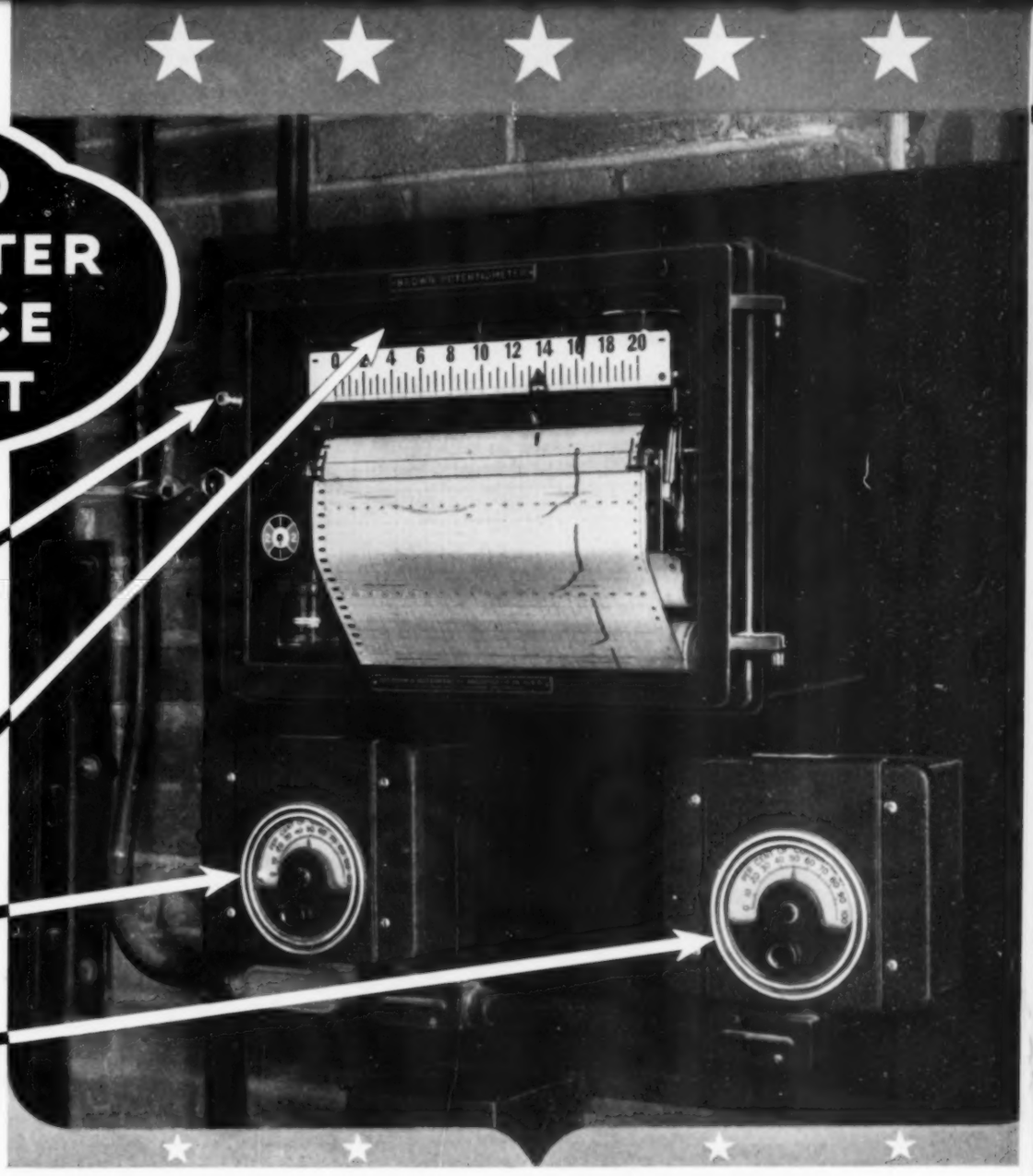

Set index to desired starting temperature.

Set Soaking Temperature Switch at desired holding temperature.

Set "Rate Control" at desired degrees per hour.

Set "Soaking Time Control" at desired time in hours and minutes.

Upon completion of program, fuel will be shut off and/or signal given.

IN the manufacture of aircraft parts at the Kellett Autogiro Corporation, Philadelphia, *Time* and *Temperature* are important factors in producing desired results.

The Brown Program Potentiometer Controller, shown above, automatically raises, holds or lowers temperatures according to a predetermined Time-Cycle Control schedule. This is accomplished by a timer mechanism operating a motor-driven control index in the instrument. By virtue of the Timer-Control index combination, program flexibility is almost unlimited. The operator merely sets the dials, as in a radio, and fixed cams, etc., are eliminated.

To the steel treater who appreciates the importance of accurate temperature measurement and positive control of furnace operation, Brown Potentiometer Controllers offer worthwhile advantages. They help to speed up and maintain manufacturing schedules along predetermined lines of increased production, standardized quality and lower costs.

They are designed to work singly or in complete coordination for the control of a single factor or complete control of an entire process. They are supplied for controlling any type of furnace . . . oil, gas or electric. You'll find Brown Instruments everywhere, on all makes of furnaces, used for every kind of work where closely held temperature is essential to "all out" production.

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To get full details on Brown Automatic Program Control Systems — Time-Temperature — write for Bulletin No. 85-17.

BROWN POTENTIOMETER CONTROLLERS

THE BROWN INSTRUMENT COMPANY, PHILADELPHIA, PENNSYLVANIA

DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.

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TO MEASURE AND CONTROL IS TO ECONOMIZE

Does PRODUCTION like this interest you?

101 EASY-FLO JOINTS PER HOUR!

That's the production one large washing machine manufacturer is getting by taking full advantage of Easy-Flo brazing alloy's **fast brazing action** and a rapid method of heating.

THE JOB . . .

A hex collar of cold drawn steel had to be joined to a steel tube, in the position shown at the right, to form a wringer post. The part is new, but after extensive experimenting Easy-Flo brazing was adopted as the best method of doing the job.

HERE'S HOW IT IS DONE

The operator, after cleaning surfaces to be joined, places the collar on the tube in its approximate position. He then slides a ring of Easy-Flo wire next to the collar and brushes on flux. Next he puts the assembled parts into an induction heating coil equipped with a fixture so designed that when the assembly is pushed down to the bottom, the collar is accurately positioned. While one assembly is heating, the operator prepares another, resulting in a steady flow of finished parts. Time per assembly is a little over ½ a minute —**101 joints per hour.**

FIND OUT WHAT EASY-FLO WILL DO FOR YOU

Easy-Flo joins ferrous, non-ferrous and dissimilar metals. Its brazing action is **fast** and the joints it makes **strong** and **reliable.** It can be used for a multitude of purposes. If you have a metal joining problem, **try it**—we'll be glad to cooperate. Send us full details and get our recommendations — or ask for a field engineer to call and give full details and a demonstration. Write for our new Bulletin No. 12 giving full details.

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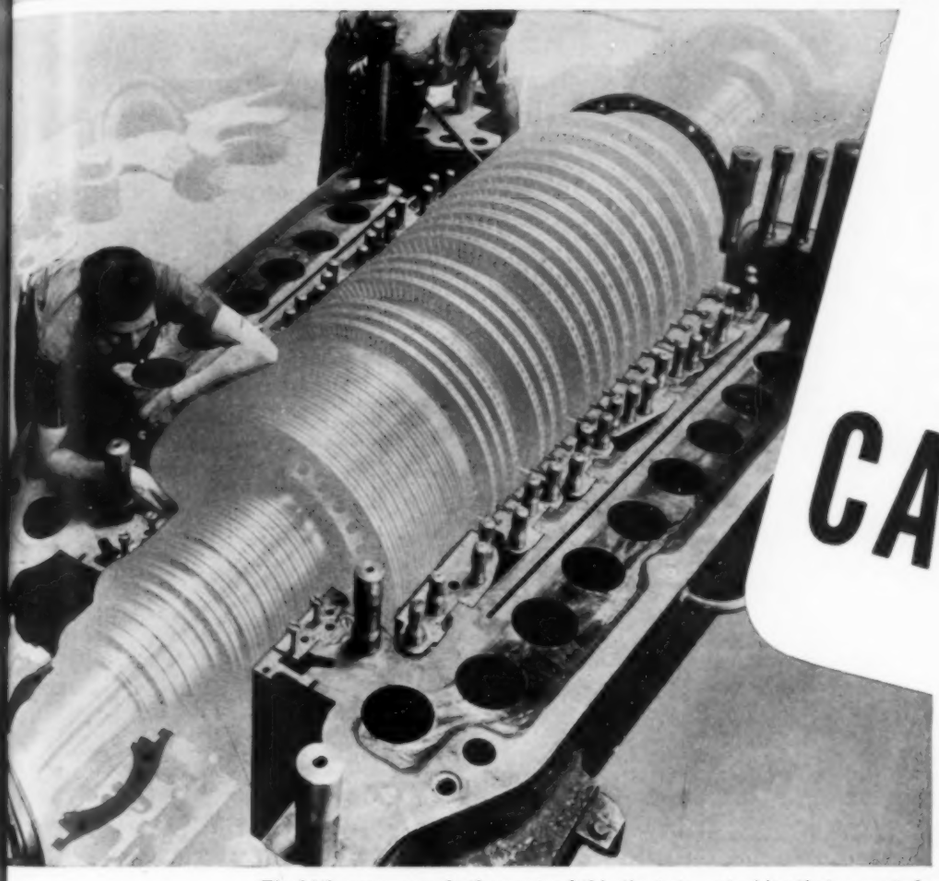
WHERE THE PRESSURE IS GREATEST AND THE GOING TOUGHEST—



they use STEEL CASTINGS

The high pressure and other parts of this giant steam turbine that are not shaded are steel castings.

Steam at pressures over a thousand pounds per square inch—temperatures over 900°F.—these conditions are tough.

Imagine them in a steam turbine, with a rotor whirling at 3,600 rpm—where tolerances are close, where expansion must be under rigid control, where metal fatigue is terrific!

That is why turbine engineers specify steel castings for the casings, blade rings, bearing shells, gland covers and dummy seal rings of steam turbines, from the largest size to the smallest.

Steel castings are proving their worth for thousands of important parts—from a few ounces up to many tons. They are so adaptable that they fit all conditions. They combine great strength, rigidity, controlled hardness and resistance to fatigue with low first cost and low finishing and assembly cost.

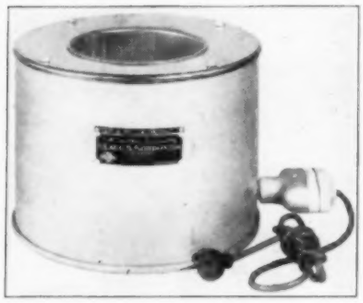
The steel foundry industry is ready to work with you on improving and modernizing your product, offering you the combined research and technical facilities of a whole industry.

Why not consult your own steel foundryman? He is ready to help you speed up production, or make a better product. Or you may write to Steel Founders' Society, 920 Midland Building, Cleveland, for information. No obligation, of course.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

The Gordon Type 1100 Portable Electric Furnace



This unique portable electric furnace designed for use at temperatures below 1100 deg. F. For use with drawing salts and oil tempering baths.

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(Write for Bulletin No. 22)

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Fuel Fired and Electric Furnaces designed for any requirement— no furnace is too large or too unusual.

1942 **1942**

SUN	MON	TUE	WED	THU	FRI	SAT
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Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

A Christmas Message . . .

In spite of wars and the confusion they bring into our lives, the Spirit of Christmas still lives, with its promise of inner peace.

May you experience an abundance of this peace . . . and its inherent joy and tranquillity . . . at Christmas and thru the New Year.

THE GATHMANN ENGINEERING COMPANY

Emil Gathmann, President